ASSEMET OF CLIMATE VARIABILITY IMPACTSE ON WHEAT PRODACTION, FARMERS' PERCEPTION AND ADAPTAION STRATEGIES: THE CASE OF DOYOGENA

WOREDA FARMING COMMUNITIES OF KAMBATA-TAMBARO ZONE,

SNNPR, ETHIOPIA

MSC THESIS

BY

MULUGETA GEBRE

HAWASSA UNIVERSITY

COLLEGE OF AGRICULTURE

APIRL, 2022

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A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, FACULTY OF ENVIRONMENT, GENDER AND DEVELOPMENT STUDIES. HAWASSA UNIVERISTY

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SCHOOL OF GRADUATE STUDIES

HAWASSA UNIVERSITY ADVISORS' APPROVAL SHEET

(Submission Sheet-1)

This is to certify that the thesis entitled "**Farmers' Perception on Climate Variability, Its Impacts and Adaptation Strategies: The Case of Doyogena Woreda of Kambata-Tambaro Zone, SNNPR."** Submitted in partial fulfillment of the requirement for the degree of **Master's** with specialization of **Climate Change and Sustainable Agriculture**, the Graduate Program of the **Climate Change and Sustainable Agriculture**, and has been carried out by **Mulugeta Gebre Id. No CCSA/0012/12,** under our supervision. Therefore, we recommended that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

Approved by advisors: _

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We, the undersigned, members of the Board of Examiners of the final open defense by Mulugeta Gebre Haydebo have read and evaluated his thesis entitled "**Farmers' Perception on Climate Variability, Its Impacts and Adaptation Strategies: The Case of Doyogena Woreda of Kambata-Tambaro Zone, SNNPR,"** examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of MSc in Climate Change and Sustainable Agriculture.

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STATEMENT OF AUTHOR

I declare and affirm that this thesis is my work and all sources of materials used for this thesis have been fully acknowledged. This thesis has been submitted in partial fulfillment of the requirements for M.Sc. degree at the Hawassa University college of Agriculture and is deposited at the University Library to be made available to borrowers under rules of the library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate. Brief quotations from this thesis are allowable without special permission, provided that an accurate acknowledgement of the source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the Head of the Program of climate change and sustainable agriculture or the

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Date of Submission: ________________

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DEDICATION

I dedicated this thesis to my Lord Jesus Christ, my mother Shaga Chufamo and my brothers Salamu and Temesgen as well as my sisters Misgana, Alimaz and Tesfanesh for their support and encouragement.

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LIST OF ACRONYMS

AGRA	Alliance for a Green Revolution in Africa
BC	Before Christ
CEEPA	Centre for Environmental Economics and Policy for Africa
CSA	Central Statistics Agency
CV	Coefficient Variation
DWARDO	Doyogena Woreda Agriculture Rural Development Office
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
GHG	Green House Gases
GDP	Gross Domestic Product
ICV	Impact of Climate Variability
ICARDA	International Center for Agricultural Research in the Dry Areas
IPCC	Intergovernmental Panel on Climate Change
KIIs	Key Informant Interviews
MNL	Multinomial Logit
NAPA	National Adaptation program of Action of Ethiopia
NMA	National Meteorology Agency
NMSA	National Meteorology Service Agency
SNNPR	South Nation Nationalist People Region
SPI	Standard Precipitation Index
SSA	Sub-Saharan Africa
UNDP	United Nations Development Program
UNEP	United Nations Environmental Policy
UNFCCC	United Nations Framework Convention on Climate Change
WRI	World Resources Institute

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Farmers' Perception on Climate Variability, Its Impacts And Adaptation Strategies: The Case of Doyogena Woreda of Kambata-Tambaro Zone, SNNPR

ABSTRACT

Climate variability has adversely affected the livelihoods of people in developing countries where a large proportion of the population is heavily dependent on agriculture. Severe and repeated rise in temperature and rainfall failures caused loss of crops and livestock which resulted in food insecurity in Ethiopia. This study aims to assess farmers' perception on climate variability, its impacts and adaptation strategies in Doyogena District.The study used multi stage sampling procedure. Purposive sampling procedure was used to select study area. Primary data were collected using key informant interviews, focus group discussions and household surveys with 181 households. Similarly, secondary data were collected from NMA and DWARDO. Descriptive statistics, MNL and SPI were used to analyze the collected data. According to the survey results, about 83% of the respondents perceive that, the rainfall amount in the study area is decreasing. However, long-term recorded 1996-2019 rainfall data showed that the annual rainfall is decreasing by the rate of –6.56 annually over the past 24 years. The mean annual rainfall was 1164.19mm with 11.5% of coefficient of variation which is less variable based on degree of variability. Similarly, 84.70% of interviewed farmers said that temperature is in increasing trend, which confirms the results from the analysis from 1996-2019 recorded data by NMA that indicated the mean minimum and maximum temperatures are increasing by 0.074°C and 0.021°C per annum respectively. The study had also shown that farmer's adaptation strategies include; using improved crop variety, mixed crop livestock system, use of irrigation, soil and water conservation, adjusting planting date and income diversification activities. The marginal effects of MNL model results also indicated that, the adaptation strategies used by farmers were significantly ($p< 0.05$) influenced by age, family size, farm land size, monthly income and livestock ownership, whereas; sex, access to extension service, access to credit service and farming experience. Therefore, improving farmers' perception of climate information, and promoting farm-level adaptation strategies such as the use of new agricultural technologies and adjusting planting date must be strengthened in the study area.

Keywords: Perception, Climate variability, adaptation strategies, MNL and Doyogena.

1. INTRODUCTION

1.1 Background of the Study

Great impacts of climate change and variability associated with natural disasters such as severe floods, prolonged droughts, landslides, ice melting, storms, untimely rains, frost, hail and hurricanes usually lead to a massive loss of human life, agricultural and livestock production losses, soil degradation, and definitely affect people's livelihood negatively (Rwanyirizi and Rugema 2013).

Climate variability has been adversely affecting the livelihoods of people in developing countries where a large proportion of the population is overwhelmingly dependent on agriculture. It has exacerbated poverty, food insecurity and vulnerability of agrarian communities in Sub-Saharan Africa (Akponikpè et al., 2010).

(AGRA 2014) ascertained that agriculture sector has a noticeable role in economic development of SSA countries. On average, it accounts for 34% of the total Gross Domestic Product (GDP) and about 65% of total population is engaged in agriculture. Reliance on natural resources for subsistence in SSA leads to land degradation, desertification and further food insecurity. This is attributed to the limited adaptive capacity to climate variability impacts.

The IPCC findings from previous reports indicated that developing countries, such as Ethiopia, will be more vulnerable to projected temperature and rainfall trends. The recent fifth IPCC report officially published in 2014a indicates warming in all four seasons over Ethiopia, which may result in more frequent heat waves. In terms of projected rainfall, the climate will be wetter, with more intense wet seasons and less severe droughts in October-November-December and March-April-May.(IPCC, 2014a)

The essentiality of Ethiopian agriculture related to climate change impacts analysis and adaptation measures is self-evidenced by agriculture's multiple roles in the country. Food security, employment, income and significant portion of GDP are drawn from agriculture. Agriculture accounts about 41 % of the GDP, 90 % of the exports, and serves as the direct source of employment and livelihood for about 85 % of the population (CSA, 2011). Generally, increased frequency of droughts, floods, rising carbon dioxide (CO2) concentration, causing increased temperature and reduced rainfall negatively affect crop production, demonstrating its sensitivity to climate variability (Deressa et al., 2009).

1.2 Statement of the Problem

Climate change is the major environmental challenges which face societies in the world. The poorest countries and the poorest peoples are suffer more than the others, even though their contribution for the change is negligible.

Climate change and variability affects agriculture, health, water resources and natural resource. Farmers of Doyogena woreda are, like farmers in any other part of Ethiopia, are suffering from Climate disruptions which have become common natural catastrophes in the country. In the study area more erratic and unreliable rainfall in the rainy seasons, is bringing drought, reduction in crop yields, increase food crises, floods, landslides and soil erosion.

The impact of climate change and variability is increasing from decade to decade and adaptations to climate variability differ from one locally. Farmers' Perception and Adaptation to Climate Change and Variability is new area of research in the selected study area. This study attempts to analyze the knowledge of farmers about climate variability and adaptation strategies and to cop up the impacts of climate variability. Current knowledge of farmers about climate variability and adaptation is insufficient for reliable prediction of climate variability and adaptations; it also is insufficient for rigorous evaluation of planned adaptation measures. So to fill gap of farmers' perception, this study has been carried out with a focus assessing farmers' perception on impacts of climate variability and adaptation strategies of the study area.

1.3 Objectives of the Study

1.3.1 General Objective

The main objective of the study was to assess farmers' perception on climate variability, its impacts and adaptation strategies in the study area.

1.3.2 Specific Objectives

- To analyze farmers' perception on climate variability in the study area
- To assess impacts of climate variability in the study area
- To identify farmers adaptation strategies to climate variability in the study area.
- To determining factors affecting farmers' adaptation strategies in the study area.

1.4. Research questions

The study attempted to answer the following research questions:

1. Did farmers perceive the existing climate variability?
2. What are the impacts of climate change/variability in the study area?
3. What are the major adaptation strategies to climate variability adopted by farmers?
4. What are the factors determining farmers adaptation strategies?

1.5. Scope and Limitations of the Study

This study was limited to Doyogena district, SNNP Region. It also focused on analyzing smallholder farmers' perception and identifying adaptation strategies to climate variability and their determinants considering time limitations. It made a comprehensive analysis of the smallholder farmers' perception and adaptation strategies to climate variability and determinant of farmer's adaptation choice in Doyogena district.

The study was clearly stated to assess farmers' perception on impacts of climate change and variability and adaptation strategies used by smallholder farmers of the woreda. However, due to time and financial limitations, the study focused only on the three selected kebeles out of 13 kebeles.

1.6 Significance of the Study

Farmers' perception to climate variability, its impacts and adaptation strategies differs from district to district and hence it needs detail study to identify the adaptation methods that fits with specific place. Hence, it enables to understand climate variability perception and identifies the most commonly used adaptation strategies among the set of options and verifies factors that significantly influence adaptation strategies.

The study provides information about household level perception and adaptation strategies with their determinants in the area. It would assist local policy makers and development practitioners in designing and formulating policies that seeks to capitalize the farmers‟ dominant adaptation strategies to reduce climate variability danger in the study area in their development intervention and build climate change resilient economy at the national level. Finally, the study can be used as a base for further studies in the area of climate variability. It will serve as source of information and reference material for studies that will be conducted on adaptation strategies against climate variability impacts.

2. LITERATURE REVIEWS

2.1. Theoretical and Conceptual Review

2.1.1 Definition of Terms

Climate Change- Refers to a statistically significant variation either in the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer).Climate change may be due to natural processes or external forces, or persistent changes in the composition of the atmosphere or in land-use due to anthropogenic factors (IPCC, 2001).

Climate change refers to ongoing changes in the global climatic system resulting primarily from anthropogenic global warming as a consequence of the increased and continuing emissions of greenhouse gases, and the loss of vegetation cover and other carbon sinks (FAO, 2008). It can also be defined as gradual changes in climate norms, notably temperature and changes in the frequency, extent and severity of climate and weather extremes, explained as a persistent change in the mean and variability of climate variables such as temperature, rainfall, humidity and soil moisture (Krishna, 2011).

Climate Variability: - Refers to variations in the mean state and other statistics (such as standard of deviations, the occurrence of extremes, etc.) of the climate on temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability) (Levina & Tirpak, 2006).

Vulnerability:-Vulnerability to climate change means different things to different people. The Intergovernmental Panel on Climate Change describes vulnerability as the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change including increased variability and downside risk (IPCC, 2001). Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2001).

Adaptation:-The IPCC (2007) defines adaptation as an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects (IPCC, 2014).

Adaptation is a process by which strategies to moderate, cope with and take advantages of the consequences of climatic events are enhanced, developed, and implemented (UNDP, 2007). It is an adjustment in ecological, social or economic systems in response to actual or expected stimuli and their effects or impacts.

Adaptive capacity:- The potential or capability of a system to adjust to climate change, including climate variability and extremes, to moderate potential damages, to take advantage of opportunities, or to cope with consequences (Smit ,2002).

Mitigation:-The IPCC (2001) defines Mitigation as an anthropogenic intervention to reduce the sources or enhance the sinks of Green House Gases (GHG).

Perception: - As Van and Hawkins (2000) define perception is the process by which we receive information or stimuli from our environment and transform it into psychological awareness. People infer about a certain situation or phenomenon differently using the same or different sets of information. The knowledge, interest, culture and many other social processes shape the behavior of an actor who uses the information and tries to influence a particular situation or phenomenon (Banjade, 2003).

2.1.2. Overview of Climate Change

Climate change is a multifaceted biological and physical process. It is impossible to precisely predict future climate conditions, but the scientific consensus is that global land and sea temperatures are warming under the influence of greenhouse gases, and will continue to warm regardless of human intervention for at least the next two decades (IPCC, 2007). According to Joel et al. (1998), the climate has changed, is changing, and will continue to change regardless of what investments in mitigation is made.

Africa is also highly stressed, has low adaptive capacity and easy vulnerable to climate change. The main consequences of negative impact of climate change or climatic hazards are poverty, unequal access to resources, food insecurity, social and political conflicts and incidences of diseases. This impact of climate change presents a considerable challenge to regional agricultural development. The Sub-Saharan African countries in particular have low adaptation mechanism and are vulnerable to the widespread effect of climate change. With this bid serious problem, GDP is predicted to lost in the coming 2100 in most part of the continent. For instance, 2-7% in part of Sub-Saharan Africa, 2-4.5% in West and Central Africa, and 0.41.3% in North and Southern Africa (FAO, 2009).

According to IPCC (2007), increase in global average temperature above the range of 1.5-2.5^{o}C will negatively influences species distribution and survival. In most developing countries where the majority of the population is dependent on natural resources based livelihoods, it has an impact on socio-economic and threat to overall sustainable development. It was predicted that during 21th century, greenhouse gases mission will increase by 25-90%. This will be continuing for future periods.

Climate change affects many sectors, including water resources, agriculture and food security, infrastructures, ecosystems and biodiversity, human health and coastal zones. Because of its innate link to natural resources, agricultural production is at the mercy of uncertainties driven by climate variation, including extreme events such as flooding and drought (Kurukulasuriya and Rosenthal, 2013).

2.1.2 Evidence of Climate Variability and in the World

The world has approximately 100 years of climate records throughout the globe. These 100 years have witnessed an increase of GHGs and change in the climate system. Extreme weather events and longer term climatic change have both exerted substantial influences on economic and social history. Climate variability, driven by fossil fuel combustion and deforestation, is a becoming threat to lives and livelihoods in every part of the world at this time (Ackerman, 2009). Evidence of climate change and variability has been presented both from empirical data and perception. In the light of incontrovertible evidences of a more fundamental shift in the climate, research in to how we could adapt to this would be paramount (Balling, 1997).

The role of human activity in its recently released Fourth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC,2003), concluded there is more than 90 percent probability that human activities over the past 250 years have warmed our planet. The industrial activities in the developed nations caused rise in atmospheric carbon dioxide levels from 280 parts per million to 379 parts per million in the last 150 years. The panel also concluded there's a better than 90 percent probability that human -produced greenhouse gases such as carbon dioxide, methane and nitrous oxide have caused much of the observed increase in Earth's temperatures over the past 50 years (IPCC, 2009).

Scientists who support the global warming and climate change and variability usually incorporate the challenges to develop a better hypothesis to explain the environmental data. Against the skeptics, IPCC and other scientists who support human induced climate change are presenting different evidences. The idea of human induced climate change, he suggested that we cause our planet to run fever and now we have entered a period of consequences. The scientific evidence is clear: global climate change caused by human activities is occurring now, and it is a growing threat to society (IPCC, 2009). (GHG) emissions of mainly carbon dioxide (70%), primarily coming from burning of fossil fuel.

2.1.3 Impacts of Climate Change and Variability in Africa

The potential impacts on rain-fed agriculture irrigated systems are still not well understood. The developing world already contends with chronic food problems. Climate change presents yet another significant challenge to be met. While overall food production may not be threatened, those least able to cope will likely bear additional adverse impacts (WRI, 2005). Habitat change is already underway in some areas, leading to species range shifts, changes in plant diversity which includes indigenous foods and plant based medicines. In developing countries, 11 percent of arable land could be affected by climate change and variability, including a reduction of cereal production in up to 65countries, about16 percent of agricultural GDP (FAO, 2005).

Agriculture is the basis for the livelihood of millions of people in the developing world. However, changes in the normal pattern of climate affects agricultural production (crops and livestock) by reducing the length of growing periods and forcing marginal areas out of production. According to reports of the (IPCC), the projected yield reduction due to climate change in some poor countries could be as much as 50% by 2020. There would be a significant decline in the production of certain agricultural food crops in Africa (millet yields by 20–76% and sorghum by 13 – 82% in Sudan, maize yields by 33% in Tanzania and predicted a reduction of wheat yield by 10.6% to 18.5% in central Ethiopia (NMSA, 2001).

The impact of climate change and variability in the agriculture sector of humid and sub -humid tropics has negative consequences. Agriculture, particularly in the sub -humid areas, is vulnerable to many environmental hazards including frequent floods, droughts, tropical cyclones, storm surges and high temperatures. Low -income rural populations that depend on traditional agricultural systems or on marginal lands are particularly more vulnerable. Agricultural vulnerability to, climate change will lead to unsteady crop production and food security will face great threat (FAO, 2005).

Similar to agricultural farming the impact of climate change and variability in the livestock production is generally negative. Heat stress and its impact on seasonal water availability have a variety of detrimental effects on livestock, with significant effects on milk production and reproduction in dairy cows, and swine fertility. Pastures and rangelands are vulnerable to the climate variability particularly increased variability of precipitation. So generally livestock distribution and productivity could be indirectly influenced by the changes in the distribution of climate variability induced livestock diseases in Africa, (IPPC, 2007).

2.1.4 Rainfall and Temperature Variability in Ethiopia

Annual rainfall is likely to decrease throughout most of the African region with the exception of Eastern Africa, where annual rainfall is projected to increase. These changes in the physical environment are expected to have an adverse effect on agricultural production. Trend analysis of annual rainfall in Ethiopia shows that rainfall remained more or less constant when averaged over the whole country while a declining trend has been observed over the northern and southwestern Ethiopia (IPCC, 2007).

According to NMA, 2007 the rainfall is highly variable both in amount and distribution across regions and seasons, the seasonal and annual rainfall variations are results of the macro-scale pressure systems and monsoon flows which are related to the changes in the pressure system. The spatial variation of the rainfall is influenced by the changes in the intensity, position and direction of movement of these rain-producing systems over the country. Moreover, the spatial distribution of rainfall in Ethiopia is significantly influenced by topography which also has many unexpected changes in the Rift valley. Central rift valley is one of the environmentally very vulnerable areas in Ethiopia. Being a closed basin, relatively small interventions in land and water resources can have far reaching consequences for ecosystems goods and services and potentially undermined the sustainable use of the area.

Ethiopia experienced a high degree of variability in rainfall from year to year and season to season. Changes in rainfall are none-uniform and highly sensitive to region. The most prominent trend has been towards reduced rainfall amounts with the main growing season (March-May) across much of the country (NMA, 2007).

Such changes have multiple effects on agricultural production and water availability for irrigation, especially north, northeast and eastern lowlands of the country. Occurring during the main growing seasons in poor countries depending on rained agriculture; these declines are socially dangerous, impacting adversely on household livelihoods and food security. Looking at the precipitation; there is inter-annual and inter-decadal rainfall variability in Ethiopia. Geographical location and topography leads the country to be vulnerable to rainfall variability.

The strong inter-annual and inter-decadal variability in rainfall make difficult to detect long term trends in the country. There is not statistically significant trend in observed mean rainfall in any season from 1960-2006. Rainfall variability is the major source of risk for farmers who depend on crop production. There are two important rains in Ethiopia, the '*Kiremt'* and '*Belg'* rain (NMA, 2007).

When we come to Ethiopian case, annual temperature has rapidly increased in the last five decades. The mean annual temperature rose by 1.3^{o}c or by 0.28^{o}c per decade during 1960-2006. The frequencies of hot days and nights have also showed an increasing trend during these times. While the average number of 'cold' days has decreased by 5.8% from 1960-2003, the average number of 'cold' nights per years has decreased 11.2% (UNDP, 2008). In the coming 100 years, the average temperature in Ethiopia has projected to increase from 23.08°c during 1961-1990 to 26.92^{o}c in 2070-2099(World Bank, 2010).

However, significant temperature difference is there among different parts of the country. While highlands in the Central North of the country will be as cold as 0.5°c, the Southeast lowlands will be as warm 37^{o}c. These extreme temperatures constrain crop production by limiting water availability and growth of many plants (Temesgen, 2007).

2.1.5 Climate Variability Impacts and Responses in Ethiopia

2.1.5.1 Impacts of Climate Variability in Ethiopia

Ethiopian climate is characterized by a history of climate extremes, such as: droughts and floods; and increase and decreasing in temperature and precipitation, respectively. The history of climate extremes, especially drought, is not a new phenomenon in Ethiopia. Recorded history of droughts in Ethiopia dates back to 250BC. Since then, droughts have occurred in different parts of the country different times. Even though there is a long history of droughts in Ethiopia, studies show that the frequency of droughts has increased over the past few decades, especially in the lowlands (NMS, 2007). In recent years environment has become a key issue in Ethiopia. The main environmental problems in the country include land degradation, soil erosion, and deforestation, loss of biodiversity, desertification, recurrent drought, flood and water and air pollution. This is due to their low adaptive capacity and high sensitivity of their socio-economic systems to climate variability and change. Sensitivity and adaptive capacity also vary between sectors and geographic locations, time and social, economic and environmental conditions within a country. Current climate variability is already imposing a significant challenge to Ethiopia by affecting food security, water and energy supply, poverty reduction and sustainable development efforts, as well as by causing natural resource degradation and natural disasters (WRI, 2005).

According to National Methodological Station Agents (NMSA) (2010), the average annual minimum temperature over the country have increased by about 0.25°c every 10 year, while the average annual maximum temperature has increased by about 0.1°c every decade. The average annual rainfall of the country showed a very high level of variability over the past years, even though the trend remained more or less constant. This was associated with greenhouse gas concentration from various human activities.

Ethiopia‟s historical contribution to greenhouse gas emissions on a global scale has been negligible and the country will not be forced to prejudice future growth and wellbeing by restricting emissions of greenhouse gases. However, as we have already explored, it stands to benefit from mitigation actions for carbon offsets (NMSA, 2010).

Generally the country was highly vulnerable to climate variability. This is because of very high dependence on rain fed agriculture, which is very sensitive to climate variability and change, under-development of water resources, low health service coverage, high population growth rate, low level of economic development, low adaptive capacity, inadequate road infrastructure in drought prone areas, weak institutions and lack of awareness (NMSA, 2001).

Vulnerability assessment based on existing information and rapid assessments carried out under National Adaptation program of Action of Ethiopia (NAPA) has indicated that the most vulnerable sectors to climate variability and change are agriculture, water resources and human health. Agriculture is the most important sector in the Ethiopian economy (Temesgen, 2007). However, productivity and competitiveness of this sector is increasingly constrained by temporal and spatial variability of climate. In addition, both droughts and floods are already common in

Ethiopia. Droughts destroy farmlands and pastures; contribute to land degradation, causes crops to fail and livestock to perish. During the 1984–5 drought, the country's GDP declined by about 10 percent and the 2002-3 drought cause over 3 percent decline (NMSA, 2001).

2.1.6 Farmers' Perception and Adaptation Strategies to Climate Change and Variability

2.1.6.1 Farmers' Perception to Climate Variability

In agrarian communities, the linkage between agriculture and climate is much more complex than others, and farmers are able to identify specific and important weather patterns. Farmers usually base their crop and other production decisions using local knowledge systems which are developed from years of observations and experiences. Local knowledge forecasts provide more than just information about the forecast. They provide a set of behavioral rules that households and communities follow when certain indicators are or are not observed. Predicting climate is also an important cultural component for farmers (Burton et al., 1992).

According to Maddison (2007), perceiving change and then deciding whether or not to adopt a particular measure is process in climate change adaptation. Whenever they have the opportunity, farmers tend to adopt new variety of measures or technologies in response to the perceived changes of weather conditions. The supports from extension workers, information gained and technologies available to them will highly influence their adaptation and response capacity. For instance, farmers use water conservation techniques whenever the rainfall patterns are changed and amounts of rain are reduced. They tend to plant different crop varieties and use short term crops with adjustment of planting dates. These variability adjustments are done when they perceive reduction in rainfall and changes in the onset and offset of rainy seasons.

According to Temesgen et al. (2011), majority of farmers were able to recognize that temperatures have increased and there has been a reduction in the volume of rainfall, still few farmers' lack the perception of change in climatic condition of their area to take steps to adjust their farming activities. The degree of farmers‟ perception on climate change also depends on its impact on farmers' livelihood, their social, institutional and economic background. It is different and depends mainly on level of education, livelihood activity, location and age.

2.1.6.2 The Adaptation Strategies to Climate Variability

Over the coming decades, climate change impacts on agriculture are likely to increase due to greater climate variability, and increased frequency and intensity of extreme events. Policymakers have largely focused on tackling climate change through mitigation of human induced emissions of greenhouse gases and sequestration of carbon in order to address the expected pressures on the agricultural as well as other economic sectors. However, it is becoming widely accepted that mitigation alone is implausible to be sufficient as a climate policy (Pielke, 1998).

Adaptation and mitigation are two different policy responses to the issue of climate change. They are however inherently linked. Since mitigation measures alone will not be able to immediately avoid global warming, adaptive measurements are needed to avert the negative consequences of climate change at the short-term. On the long-term, mitigation measures will be able to avoid further warming or even reduce the effect (Parry et al., 2007).

A plenty of studies have consequently emphasized the need to take adaptation in addition to mitigation strategies. The goal of an adaptation measure should be to increase the capacity of a system to survive external shocks or changes. The IPCC (2001) noted that adaptation through changes in processes, practices or structures is an essential element in reducing adverse impacts or enhancing beneficial impacts of climate change. Adaptation strategies are also required to overcome the expected adverse impacts from higher temperature and changing rainfall patterns (Kurukulasuriya and Mendelsohn, 2007). The main aspect of climate change adaptation constitutes building resilience which is the capacity of a system to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes (FAO, 2003).

There are many different strategies that the farmers can implement to reduce the risk of climate change impacts. Farmers use different adaptation strategies that fit with the types of the problems caused by climate change they faced. This is due to the fact that impact of the climate change is unevenly distributed over different geographic areas and hence the adaptation mechanisms also vary with types and level of the impact of climate change (IPCC, 2007).

A number of adaptation strategies that the farmers used to reduce the impact of climate change are identified in different literatures. These include; changing planting dates, changing crop variety, mix crop and livestock production, planting short season crop, planting trees, decrease livestock, moving animals or temporary migration, change livestock feeds, soil and water management, change from livestock to crop production, change animal breeds, irrigation or water harvesting, and seek off-farm employment are among some of the several strategies available to enhance social resilience in the face of climate change (Nhemachena and Hassan, 2007).

Studies carried out independently by the World Bank (2010), also showed that diversification, using different crop varieties, changing planting dates, planting trees, adoption of drought tolerant and early maturing crop varieties, changing cropping densities, water harvesting techniques, increased use of soil and water conservation techniques or soil erosion prevention programs, increased use of irrigation and or use of irrigation techniques, changing fertilizer application, pesticide application, applying different feed techniques, the pastoral system or the herd composition, improvement or rehabilitation of terraces, home-garden agriculture are among the common adaptation strategies farmers carry out in response to climate change.

Even though there are a wide range of adaptation options, there is no assurance that a particular farmer will undertake adaptive response. The extent to which adaptation strategies are implemented varies among individual farmers depending on their capacity and willingness to adopt (Crimp et al., 2010).

There are factors that are restricting adaptive capacity and willingness to adopt as a potential source of limits and barriers to adaptation. A complex mix of conditions determines the capacity of systems to adapt. The main features of communities or regions that seem to determine adaptive capacity are biophysical, economic, social, technological, information, skills, infrastructure, and institutional characteristics (Munasinghe and Swart, 2005).

2.2. Review of Empirical Literature

2.2.1. Farmers' perception to climate change and variability

Fosu-Mensah et al. (2012) conducted study on farmers' perception and adaptation to climate change and variability in Sekyedumase district in Ghana. Results showed that about 92% of the respondents perceived increases in temperature, while 87% perceived decrease in rainfall over the years. Even though the communities are highly aware of climate issues, only 44.4% of farmers have adjusted their farming practices to reduce the impacts of increasing temperature and

40.6% to decreasing rainfall, and mentioned that lack of funds as the main barrier to implementing adaptation measure.

A research was undertaken by Bryan et al. (2009) on adaptation to climate variability in Ethiopia and South Africa which examined farmers‟ perceptions of climate change in Ethiopia and South Africa. The result showed that even though farmers perceived changes in temperature and rainfall, a large percentage of farmers did not make any adjustments to their farming practices. Belaineh et al. (2013) also found that there are nearly unified perceptions of climate variability and change among gender and social groups.

Abid et al. (2015) studied farmers‟ perceptions of and adaptation strategies to climate change and their determinants in Punjab province of Pakistan. The results demonstrated that awareness of climate change is widespread throughout the area, and farm households make adjustments to adapt their agriculture in response to climatic change.

A study has been conducted by Nega et al. (2015) on perception of climate change and its impact by smallholders in pastoral/agro pastoral systems of Borana, South Ethiopia. The results suggested that most participants perceived climatic change and its negative impact on agriculture and considered climate change as a salient risk to their future livelihoods and economic development. Different levels of perception were expressed in terms of climate change and the impact on traditional rain-fed agriculture. Age, education level, livestock holding, access to climate information and extension services significantly affected perception levels. Solomon et al. (2016).

Gadédjisso-Tossou (2015) conducted a study on understanding farmers‟ perceptions of and adaptations to climate change and variability the case of the Maritime, Plateau and Savannah Regions of Togo. The analysis of farmers‟ perception to climate change revealed high increase in temperature and decrease in rainfall. These results were in accordance with the trend analysis of climate data records in the study area particularly on the temperature.

Adeoti et al. (2016) examined farmers‟ vulnerability, perception and adaptation to climate change in Kwara State using descriptive statistics and MNL model. The study revealed that majority (84%) of the farmers believed that temperature had increased while about 65.8% noticed that rainfall had declined. Abrham et al. (2017) also investigated smallholder farmers‟ adaptation to climate variability and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia using a descriptive statistics and MNL model. The result showed that 90% of farmers have already perceived climate change and 85% made attempted to adapt.

Wondimagegn and Lemma (2016) conducted a study on climate change perception and choice of adaptation strategies base on empirical evidence from smallholder farmers in east Ethiopia. According to this study, majority of farmers in the study area are aware of climate variability patterns and their adverse effect on income, food security, diversity, forest resources, food prices and crop and livestock diseases. Results showed that, from the sample households, more than 95% perceived the rise in average temperature and about 86% perceived the decrease in precipitation over the years.

2.2.2. Adaptation Strategies to Climate Variability and Their Determinants

Temesgen et al. (2009) identified the major methods used by farmers to adapt to climate variability in the Nile Basin of Ethiopia, the factors that affected their choice of methods and the barriers to adaptation by employing multinomial logit (MNL) model. Based on their findings, the level of education, sex, age, and wealth of the head of household; access to extension and credit, information on climate, social capital, agro-ecological settings, and temperature found to influence farmers' choices.

Gbetibouo et al. (2010) conducted a research on climate adaptation strategies of farmers in the Limpopo Basin of South Africa. The results showed that even though many farmers noticed long-term changes in temperature and precipitation, most could not take remedial action. The common adaptation responses reported included diversifying crops, changing varieties and planting dates, using irrigation, and supplementing livestock feed. A MNL analysis of climate adaptation responses noted that access to water; credit, extension services, off-farm income, employment opportunities, tenure security, farmers‟ asset base, and farming experience are the key that enhanced farmers' adaptive capacity.

Aemro et al. (2012) investigated climate variability and adaptation strategies of smallholder farmers in Babilie District, East Harerghe Zone of Oromia Regional State of Ethiopia. The results from the MNL analysis showed that sex, age, and education of the household head; family size, livestock ownership, household farm income, non/off farm income, access to credit, distance to the market center, access to farmer-to-farmer extension, agro-ecological zones, access to climate information, and extension contact found to have a significant impact on climate variability adaptation strategies.

Belaineh et al. (2013) examined smallholder farmers" perceptions and adaptation to climate variability and climate change in Doba District, West Hararghe Ethiopia. The adaptation strategies used in MNL model were crop diversification and the use of soil and water conservation practices, integrated crop and livestock diversification, engaging in off-farm income activities and rainwater harvesting. It was found that agro-ecological locations, sex, family size, plot size, off-farm income, livestock holding, frequency of extension contact and training were the determining factors influencing adaptation strategies.

A research done by Gebru et al. (2015) on farmers' climate variability adaptation options and their determinants in Tigray Region, North Ethiopia in which descriptive statistics were employed to assess adaptation options while the MNL model was used to identify factors influencing households choices. The results revealed that farmers use change in crop type/ variety, soil and water conservation practices, crop diversification, change in planting date and irrigation practices as climate change adaptation options. Educational level, age, sex of the household head; farm income, access to extension service, access to credit, access to climate information and agro-ecological settings were the most important determinant factors that significantly affected the choice of farmers to climate change adaptations.

Solomon et al. (2016) undertook a research on perception and adaptation models of climate change by the rural people of Lake Tana Sub-basin, Ethiopia by employing Heckman probit and MNL models. The MNL model results revealed that age, educational level, wealth status, agricultural extension services, and distance to the nearest health center are found to be significant for determining climate change adaptation.

A study by Adeoti et al. (2016) examined farmers' vulnerability, perception and adaptation to climate variability in Kwara State using descriptive statistics and MNL model. The econometric investigation revealed that education of household head, farming experience, land ownership, rainfall and temperature were the most relevant and significant factors that determined the farmers' choice of adaptation strategies to climate variability in the study area. The major barriers to adaptation include lack of information on adaptation methods, land tenure problem and inaccessibility to credit.

Abrham et al. (2017) investigated smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia using a descriptive statistics and MNL model. It is found that farmers made attempted to adapt using practices like crop diversification, planting date adjustment, soil and water conservation and management, increasing the intensity of input use, integrating crop with livestock, and tree planting. The econometric model result indicated that education, family size, sex, age, livestock ownership, farming experience, frequency of contact with extension agents, farm size, access to market, access to climate information and income were the key factors determining farmers' choice of adaptation practice.

2.3. Conceptual Framework of the Study

Currently climate change and variability is a serious global issue; it is manifested through different process, such as increase in temperature, rise in sea level, variability on rain fall etc. and it has adverse impact on human being directly or indirectly. In order to minimize the adverse impact of climate variability taking adaptation strategy is an important option. But, in order to take different adaptation measures, first farmers have to perceive the change and variability on crop production and identifying the factors that hinder and facilitate adaptation practices is crucial because, they have influence on the implementation of adaptation measures to climate variability impact.

There are different factors related to impact climate variability adaptation Practices. These factors are mainly demographic, social- economic and institutional. The factors may positively and/or negatively affect farmer's adaptation behavior. More specifically factors influencing adaptation of climate variability measures include: education, sex, family size, farming experience, access to credit, off- farm income, farm size, and access to climate related information and extension contact service (Deschenes, 2006). The factors mentioned above can be represented by the following figure 1 and then discussed below.

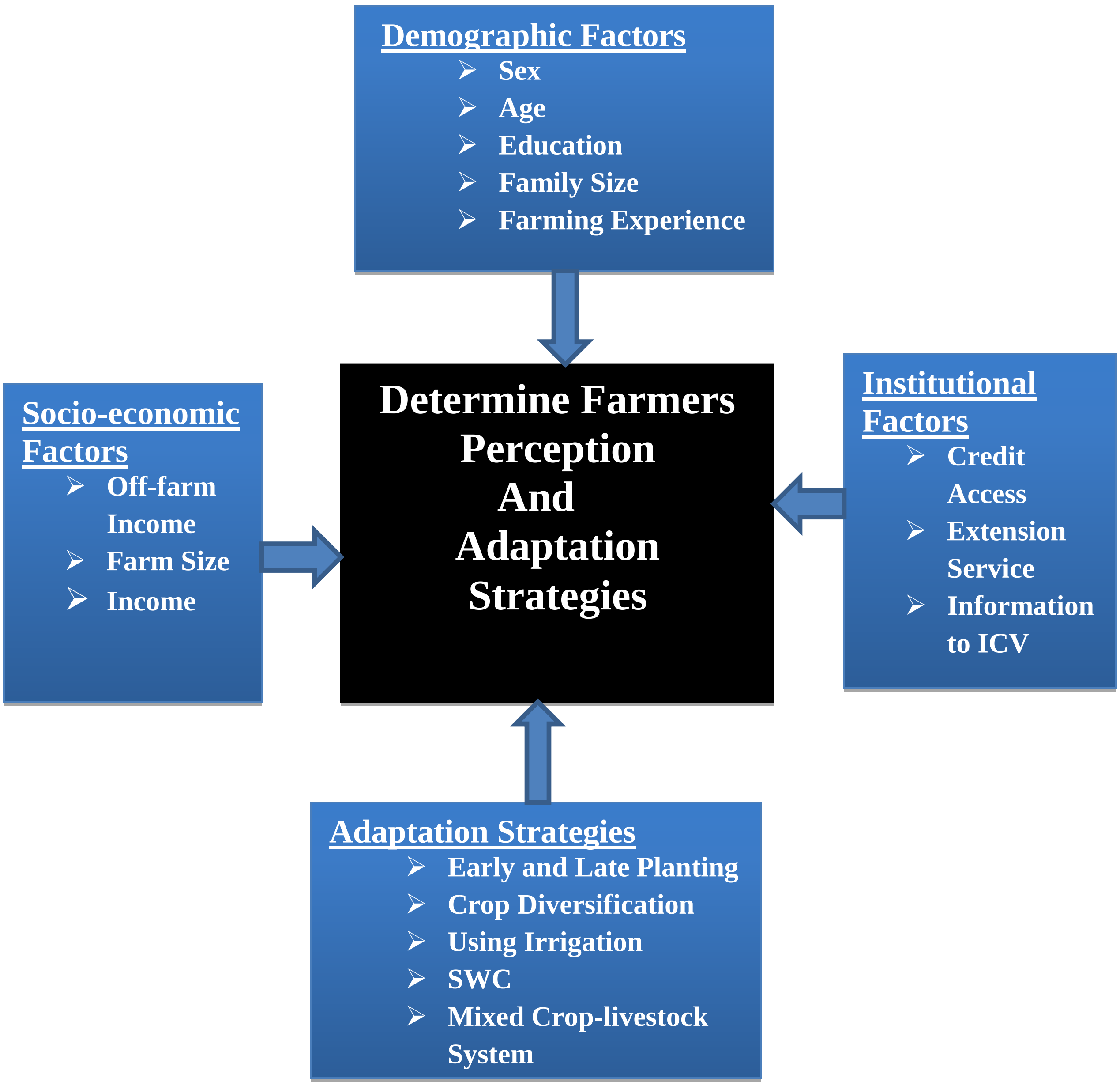

Figure 1 Conceptual framework

Source: Own synthesis based on literature reviews

3. RESEARCH METHODOLOGY

3.1. Description of the Study Area

Doyogena Woreda is located in Kembata Tembaro Zone in South Nation Nationality and People Regional State. It is one of the 11 administrative wereda's of Kembata -Tembaro Zone .It has a total area of about 17,663.59 hectares and almost all area is inhabited by people (WARDOR, 2021).

The Woreda is bordered, on the south by Kacha-Bira Woreda, on the West and North by the Hadiya Zone and on the East by Anigecha woreda. Astronomically, the study area is located between 7º15' 00''N -7º31' 00''N latitude and 37º44 ' 00''E - 37º53 '00''E longitude.

Based on information that was taken from the Woreda transport office (2021), the study site is found at 258 Km away from Addis Ababa to south, 171 km away from regional center Hawassa to west and 67Km away from Durame the district administration center to south north.

Map of the Study Area

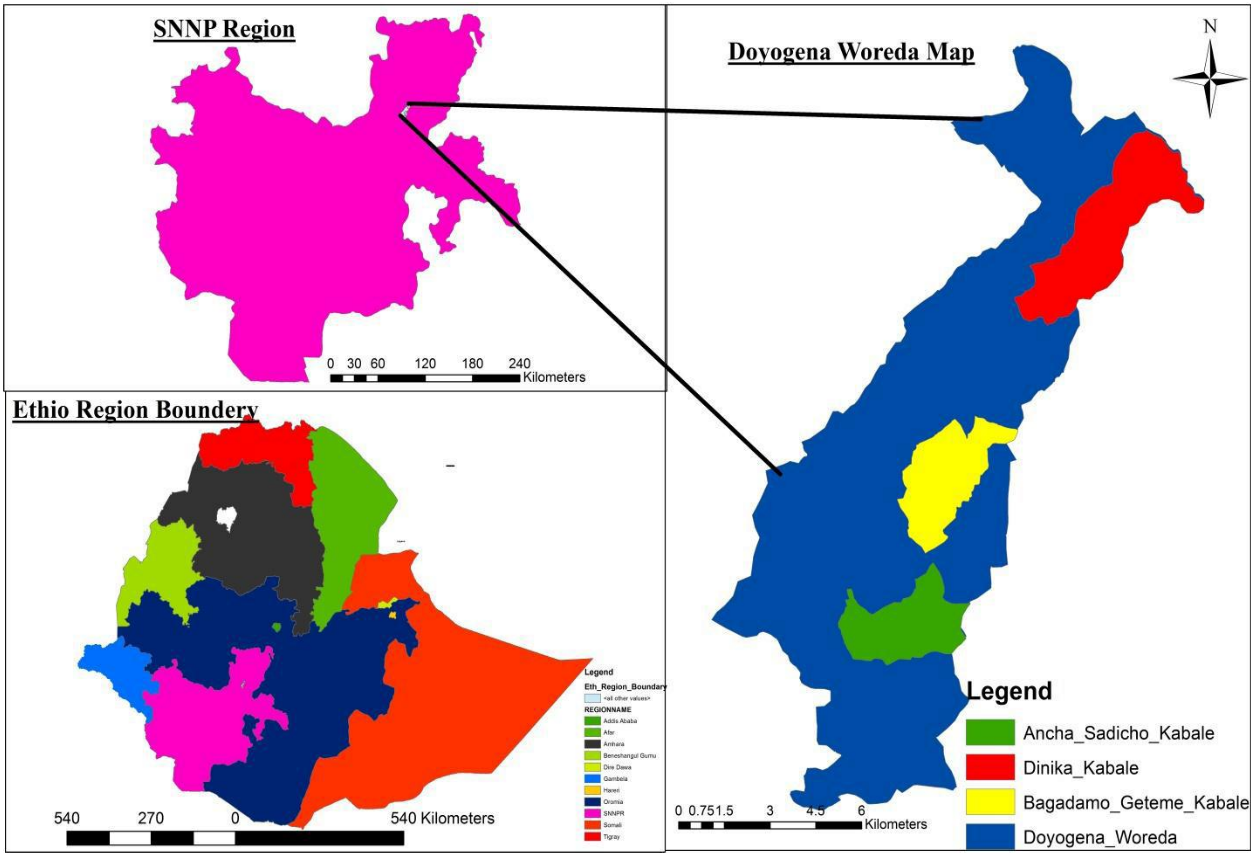

Figure 2 Map of the Study Area

Source: Computerized from Ethio GIS (2021)

The nature of topography of a particular geographic entity has multi-dimensional implications upon the development of physical infrastructure, human way of life, the type of production of crops, the land use conditions and the type of flora and fauna exists. The relief of the study area is characterized by some plain, plateau, rugged and ridges terrain, which are generally high lands. The elevation range is between 900m-1800m above sea level; the highest place in the study area is Gomorra hill which is approximately 1800m peak. The slopes of the study area are categorized as gently sloping, moderately sloping and steep slope. Therefore, majority of land in study kebeles are moderately sloping slope (WARDOR, 2021)

Climate is one of the elements of the physical environment which has a pronounced impact on settlement pattern, human way of life, the type of soil, economic activities, flora and fauna existed and developed so forth.

Among different climatic elements temperature and rainfall have a considerable impact in suchan agrarian country like Ethiopia and in the study area. The climate of the study area is characterized by moderate temperature and rain fall and it is categorized under Dega and Woina Dega Ethiopian agro- ecology zone. According to, the Doyogena woreda meteorological data, the annual average minimum and maximum temperature of the study area is 12ºc and 16 ºc respectively. Its mean annual temperature is about 15.5ºc. The total annual rainfall of the study area ranges between 1100-1200mm (WARDOR, 2021).

3.2 Research Design

To undertake the study the researcher used qualitative and quantitative research method. Through qualitative method the data was collected by structured questions, semi-structured questions, focus group discussion and structural interviews, field survey intended to take of responses that the respondents give meaningful information about the farmers’ perception on impact of climate variability and the adaptation strategies that implement in the study area. The descriptive design employ data to analyze the data and it is appropriate method which enables the researcher to evaluate farmers’ perception on impact of climate variability and its stresses in the study area.

3.3. Sampling Techniques and Size Determination

The study used a multi stage sampling procedure. First Doyogena woreda was purposely selected since; it is one of the susceptible to problems related to impacts of climate change and variability in the SNNP Region (WARDO, 2021). Second, 3 kebeles were selected due to agro-ecological variation (micro-climate variations) and proximity out of the 13 rural kebeles based on information from Woreda Agricultural Office. Then, 181 households were selected by using systematic random sampling technique with probability proportional size for the reason that it has advantage in providing information on large group of people, within limited time and a cost effective manner (Geofrey et al., 2005). In order to reduce sampling error and determine the required sample size, the researcher was used Yamane's (1967) simplified formula at 95% confidence level and 7% level of precision as shown below.

$$\mathbf{n} = \frac{\mathbf{N}}{\mathbf{1+N(e)2}} \quad \text{...1}$$

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

$$\mathbf{n} = \frac{\mathbf{N}}{\mathbf{1+N(e)2}} = \frac{\mathbf{1584}}{\mathbf{1+1584(0.07)2}} = 181$$

Table 1 Sample Household Size used for the Study from each Kebeles

No	Name of sampled kebeles	Household Size	Sample Size
1	Anicha Sadicho	532	61
2	Begedamo Getame	544	64
3	Dinka	508	56
Total		**1584**	**181**

Sampling HHs

3.4. Data Types and Sources

The study used both primary and secondary data comprising of qualitative and quantitative variables. Primary data were collected from sample households, focusing on socio- economic & demographic characteristics of households in the study area and other essential information related to the research objectives. Additional data were also collected using household survey, FGDS and Key Informant Interviews.

Whereas, secondary data were collected from; office reports and documents of Governmental organizations (GO) and Non-Governmental organizations (NGO), from National Meteorology agency (NMA), Doyogena Woreda Agriculture and Rural Development Office, published and unpublished materials to supplement analysis of the impacts of climate change and variability and adaptation strategies of the farmers in the study area.

3.5 Data Collection Techniques

The primary data were collected through various way including:-

Household survey: It is the commonly used approach in various data collection activities and it was the major source of data collection for this study. Structured questions were also prepared to collect data to achieve the major research objective areas. Socio- economic and demographic characteristics of respondents were also included in the questionnaire. In order to reduce time and communicate easily with the respondents the questionnaires were translated in to kambatisa Afoo. The respondent sample farmers were then characterized by socioeconomic and demographic profile for the study such as; sex, age, education level, farm-land size, family size, monthly income, farm experience, livestock ownership,….etc

Key Informant Interviews (KIIs) were aimed to obtain detail information on the issues. To get detailed information, the researcher use semi structured interview method because of its flexibility and makes clear any time when there is ambiguity. The key informant interview was conducted with development agents (3), local leaders (3), model farmers (3) and 1 woreda agricultural development office representative, about the cause and impacts of climate variability in the study area.

Focus group discussion (FGD) helps to generate data on group dynamics, and allows a small group of respondents to guide by a skilled moderator, to focus on key issue of the research topic. The researcher selected six respondents in each kebele based on socially respected within society and are known to have better knowledge on the present and past environmental, social and economic status of the study area.

At each kebele, one focus group discussion will hold. The focus group discussions were made with member of select educated person (1), local elder (2), religious leader (1), women (1) and 1 young farmers of the sample, kebele's. The main purpose of focus group discussion is to understand the level of perception of the people about climate variability impacts, its cause and their responses. The major discussion topics are on the local community understanding of climate variability and its cause, major hazards and their impact and adaptation strategies and barriers to employ them effectively.

Secondary data: rainfall and temperature data were obtained from National Meteorological Agency (NMA), while data from Woreda Agricultural and Rural Development Office (WARDO). The temperature and rainfall trends were, thus, compared with the perception of climate variability trends and with its impacts.

3.6. Data entry and Analysis

Household level data were entered and compiled in one file comprising all sections of the questionnaire after which data cleaning was followed to ensure the removal of all mistakes and errors in order to have a clear data set ready to be used in the analysis. The cleaned data set were then exported first to Microsoft Excel and to the STATA version 14.1 to come up with graphs and tables indicating the results to discuss on.

3.6.1. Descriptive Statistics

Descriptive statistics such as mean, frequency and percentage were used to characterize demographic and socio-economic profile of the farmers, farmer perceptions on changes in long-term temperature and rainfall changes as well as various adaptation measures being used by farmers, and the main challenges which prevent the practicing of adaptation strategies. STATA version 14.1 and Microsoft-excel were used for the analysis of quantitative data. The temperature and rainfall trends were, compared with the Maize data and the respondents" perception of climate change trends and its effect. Data which were obtained from key informant and FGDs were analyzed using narration.

3.6.2. Specification Empirical Model

Multinomial Logit Models (MNL) was used to identify the major factors determining adaptation strategies to climate change and variability. The MNL model was used by many researchers to model climate change adaptation strategies of smallholder farmers (Temesgen et al., 2010). Therefore, the multinomial legit model is appropriate to model of climate change adaptation strategies of smallholder farmers in the study area. The choice of a given adaptation option is discrete because it is chosen among other alternative option. Let Pij represent the probability of choice of any given adaptation option by small farm households, then equation representing this will be,

$$P(ij)=\beta o+\beta 1X1+\beta kXk+e \text{..} 2$$

Where i takes values (0, 1, 2, 3, 4, 5, 6), each representing the choice of adaptation option (no adaptation =0, using mixed crop livestock system =1, use improved crops variety=2, use of irrigation =3, soil and water conservation=4, adjusting planting date=5, and diversifying income sources =6). X1 are factors affecting choice of an adaptation option, β are parameters to be estimated and e is randomized error.

Where Zj is a choice and Zk is alternative choice that could be chosen (Greene, 2000).

The model estimates are used to determine the probability of choice of an adaptation option given j factors that affect the choice Xi. $\ln (Pi\ j/Pi\ k) = \alpha + \beta 1X1 + \beta 2X2 + ... + \beta k\ Xk + e$...3

Pij and Pik are probabilities that a farmer will choose a given adaptation option and alternative adaptation option respectively. ln (Pij/Pik) is a natural log of probability of choice j relative to probability choice k,α is a constant, β is a matrix of parameters that reflect the impact of changes in X on probability of choosing a given adaptation option , e is the error term that is independent and normally distributed with a mean zero.

Before running the model, it is useful to look into account the problem of multi-co linearity among the independent variables. The existence of multi-co linearity problem between explanatory variables of the study was tested by using Variance. Inflation factor (VIF) for continuous explanatory variables and Contingency Coefficient (CC) for discrete explanatory variables. Thus, it can be defined as: -

VIF or CC (Xi) = $(1 - Ri^2)^{-1}$………………………………… 4

Where, R^2 is the multiple correlation coefficients between explanatory variables.

The larger value of R^2, the higher the value of VIF or VCC (Xi), causes multi co linearity in the variable (Xi).

Description and Operationalization of Key model Variables

1. Dependent Variables

Dependent variable of the model: in the findings there were some common adaptation strategies, which are all, explained by similar explanatory variables, and were identified:

I. Mixed crop livestock system: A mixed crop-livestock farming system consists of integrated crop and livestock activities. Field crop production depends on the supply of draught animals and animal manure. Draught animals play a key role in tillage of land while animal manure fertilizes field crops. Livestock in this system depend on extensive grazing of natural and crop residues during the dry season. This is a closed system in which waste products of crops are used by livestock, which in turn return its own waste (manure) back to the crop field.

II. Use of improved variety: This includes planting of short duration and drought tolerant, pest and disease resistant variety.

III. Using irrigation: Includes irrigation development from rivers or lakes in order to cope up with the challenges of climate change and variability.

IV. Soil and water Conservation: Includes soil erosion preservation, management and care of soil in order to make it suitable for their crops, dam construction, conservation of rain water for watering the crops in times too little rain, ground water harvesting and agro forestry.

V. Changing date of planting: This means that farmers could change the date of planting and harvesting crop with respect to the change in the climate (early or late planting and harvesting) that survive in adverse climatic conditions.

VI. Income Source diversification: diversifying source of income like on farm and off farm systems to increase the income of the household.

2. Independent Variables

The independent variables are those variables which are expected to have influence on the dependent variable. The independent variables that are hypothesized to affect the farmers" adaptation decision of various factors, such as:

I. Sex household head (SEXHH): is the femaleness or maleness of household head. It is dummy variable (0 for female and 1 for male). It was hypothesized that male headed households are more adapted to climate change than female headed households.

II. Age of household head (AGEHH): This is continuous variable defined as the number of years of the farm households starting from the year of birth. Older people have relatively richer experiences of the social and physical environments as well as greater experience of farming activities (Haile et al., 2005). Hence, it was hypothesized that age positively or negatively affects adaptation measure to climate change and variability of the farm households.

III. Level of Education of the Household head (LEDUC): number of years spent by the heads of the household for acquiring education. As the level of education of the household head increase, the farmers' proximity for new information and the probability of accepting new technology also increase. Hence, it was hypothesized that levels of education positively affect adaptation measure to climate change and variability of farm households.

IV. Family size (FAMSIZE): family size is the total family number of the household. The existence of large number of children under age of 15 and above 65 in the family could affect adaptation measure of the farm household. Hence, it was hypothesized that the family size are positively or negatively affect household adaptation measures to climate change and variability.

V. Farm land size (FMLSIZE): Farm land size is the total landholding of the household that uses for the farming activities. The farm households with holding large farm land are positively affect the use of adaptation measures to the climate change and it measures in hectare. Therefore, the variable is continuous and its expected was a positive sign for the farmer's adaptation measures to climate change and variability.

VI. Livestock Ownership (LVSOWSH): livestock are the major source of income in rural area where mixed farming is practice. Particularly the ownership of farm oxen forms the cornerstone of farm economy in the rural households. It determines the household's level of vulnerability to climate change impacts. This is due to the fact that livestock is essential for farm household to use as for harvesting, transportation and also for financial purpose by selling them. This implies that farmers with more numbers of the livestock is the richer and can respond to the adverse effect of climate change through adaptation method. This is a continuous variable and expected a positive sign for the farmers who used adaptation measures to climate change.

VII. Monthly income (MATHLINC): is an income return to the household from different activities. This is a continuous variable and expected a positive sign for the farmers' adaptation strategies to climate change.

VIII. Farm experience (FRMEXP): The farming experience of the household head is expected to be positively related to undertaking adaptation. A farmer with more experience would know when climate change is occurring in the area and which methods work well in that specific agro-ecological zone.

IX. Access to credit service (ACREDIT): The availability of credit is important for the farmers in order to make adaptation strategies. It is dummy variable indicating 0 if the farmers have access to credit 1 otherwise. Credit can be used as for the farmers to introduce new technology, to buy modernize crop, fertilizers and oxen. Therefore, thus was expected a positive sign for the farmers who are used adaptation strategies to climate change and variability.

X. Agricultural extension service (AGEXS): This is a formal service and plays a great role that affect for farmers‟ adaptation measures to climate change and variability. This variable is also a dummy which represent 1 if farmers get agricultural extension service 0 otherwise and the expecting sign was a positive

Table 2 Expected Signs on how the Explanatory Variables were Influence Adaptation to Climate Variability

Explanatory Variables	Definition	Measure	Expected Sign
SEX	Sex	Dummy, takes the value of 1 if male and 0 otherwise	±
AGE	Age	Continuous	±
FAMSIZE	Family size	Continuous	±
LEDUC	Educational level of respondent	Continuous	+
FRMEXP	Farm experience of respondent	Continuous	+
FLDSIZE	Farm land size(ha)	Continuous	+
MATHLINC	Monthly income	Continuous	+
EXTSERV	Access to Extension services	Dummy	+
ACCRSRV	Access to credit service	Dummy	+
LVTKOWSHP	Livestock ownership	Continuous	+

Source: Own summary from literature review

3.6.4 Standardized Precipitation Index (SPI)

The SPI was used to identify drought during the period under consideration using annual rainfall data. The SPI is a statistical measure to detect unusual weather events and then to determine how often droughts of certain strength are likely to occur. The practical implication of SPI-defined drought, as the deviation from the normal amount of precipitation, would vary from one year to another, it can be calculated as:

$$\mathbf{SPI} = \frac{Xi - X}{\sigma} \quad \text{..} \; \mathbf{7}$$

Where; SPI refers to rainfall anomaly (irregularity) on multiple time scales; x represents annual rainfall in the year t; x- "represents the long-term mean rainfall; and $\boldsymbol{\sigma}$ represents the standard deviation over the period of observation (Woldeamlak, 2009). Hence, the drought severity classes are: extremely dry (SPI < -2); moderately dry (-1 > SPI >-1); severe drought (-2 > SPI > 1.5); near normal -1 < SPI> 1; moderately wet (1 < SPI >1.5); very wet (1.5 <SPI <2) and extremely wet (SPI >2).

Intra seasonal rainfall variability was analyzed using the coefficient of variation (CV).

According to (Abate, 2009) CV % values are classified as follows:

<20% as less variable,

20-30% as moderately variable and

>30% as highly variable.

CV= SD /$\bar{X}$ *100...8

Where, CV is Coefficient of Variation, SD is Standard Deviation and X- is m

4. RESULTS AND DISCUSSIONS

This chapter provides detailed information on each section here in. The chapter has sub sections such as demographic and socio-economic characteristics of the farming households, impacts of climate variability on their livelihood, perceptions on adaptation practices and etc.

4.1. Demographic and Socio-economic Characteristics of the Farming Households

This sub-section emphasizes on demographic and socio-economic characteristics of the household that play important role in agricultural and livestock production such as sex, age, household size, marital status, education level, farming experience, employment status and household income.

Sex of the Household Head

Sex of the household determines access to information provided by extension agents on adaptation measures for impact of climate variability. Due to cultural barriers most of the time male extension agents tend to work with male headed households. This situation deprived female headed household from access to information and limited their perception of the climate variability problem and reduces their ability and willingness to use adaptive measures.

Most of climate variability adaptation measures were more labor intensive which were difficult to be performed by female headed household. As shown in the (table 3), the survey results reveal that from 181 samples of respondents (80.2%) were male and (19.8%) were females. In the area a woman takes the house hold responsibilities in house (child care, food, processing and harvesting, fetching water from long distance).

Age of the household head

The survey result showed that highest proportion of the respondents (34.8%) was lies between 46 and 65 years, while only 12.2% was between 18-25 years (Table 3). This implies that both young and old people were involved in farming activities. The older farmer, the more experienced he/she is in farming and more exposure he/she has had to the past and present climatic conditions over longer periods of time. The age of household head can be used to capture farming experience.

Marital Status of the Household Head

Majority (81.2 %) of the of household heads are married in the study area, while only 7.2% and 11.6% are single and widowed respectively (Table 3). As the majority of the household heads are married, there is advantage for these households to increase their levels of crop production and come up with efficient adaptation measures to climate change and variability than other household heads (single, divorced, and widowed), because they share their ideas on how to improve their main economic activity which is mainly agriculture.

Family size

The family size of respondents was higher in which about 42.5% of the sampled farmers had 6-9 family members, 33.7% have more than 9 (Table 3). This that means about 76.2% family sizes was greater than 6 persons per household.

The result showed that large household size might have positive impact in the adaptation strategies especially if members fully participate in adaptation practice to climate variability.

Educational Status of the Household Heads

In relation to the educational status of sampled households, the survey result implies that from the total sampled household heads 34.8%, 29.8% and 14.3% were illiterate, can read and write and juniors school level respectively. (Table3). Thus, households with better education are more aware of existing climate variability related problems and more likely to practice adaptation measures.

Household land size

Data collected on possession of land revealed that out of the total 181 respondents 41.4% acquired 0.5-1 hectares, 38.1% acquired 1-1.5 hectares, 17.6% acquired 1.5-2 hectares and 2.9% acquired >2 hectares (Table 3). This indicates about 80% of the farmers acquired < 2 hectares and unable to cop up with climate change impacts. Some studies found farm size to have positive influence on farmers' perception on climate variability.

For instance, Ehiakpor et al., (2016) noted that farmers with larger farm sizes are more likely to perceive climate variability than their counterparts with smaller farm sizes.

Table 3 Socio-economic and Demographic Characteristics of the Respondents.

No	Characteristics	No. of Households n=181	Percentage (%)
1	**Sex of households**		
	Male	145	80. 2
	Female	36	19.8
2.	**Age of the household head**		
	18-25	2 2	12.2
	26-35	33	18.2
	36-45	52	28.7
	46-65	63	34.8
	>65	18	6.1
3	**Marital status**		
	Married	147	81.2
	Single	13	7.2
	Widowed	21	11.6
4	**Family size**		
	1-2	19	10.5
	3-5	24	13.3
	6-9	77	42.5
	>9	61	33.7
5	**Educational status**		
	Cannot read and write	63	34.8
	Primary(1-4)	54	29.8
	Secondary(5-8)	26	14.3
	High school(9-12)	21	11.6
	College	17	9.5
6	**Household land size (hectare)**		
	0.5-1	75	41.4
	1.01-1.5	69	38.1
	1.51- 2	32	17.6

>2	5	2.9

Source: household survey result in the study area, 2021

Farming Experience

The household survey result shows that, 42.7% of the respondents have got farming experience of more than 30 years, while 27% are with 21-30 years of experience (Table 4). This result indicates that more than two-third of the respondent farmers is more experienced (more than 20 years) in farming practice in the sample kebeles so more ability to adapt climate variability.

Table 4 Farm Experience of Respondents

Years	Households	Percent (%)
0	5	2.8
1-5	7	3.8
6-10	16	8.8
11-20	27	14.9
21-30	49	27
>30	77	42.7

Source: household survey result in the study area, 2021

Source of Income

The household survey results revealed that, income sources for the majority 64.5% of the sample households are from on-farm activities (Figure 3). However, non-farm activities and off farm activities are not significantly adopted in the sample areas.

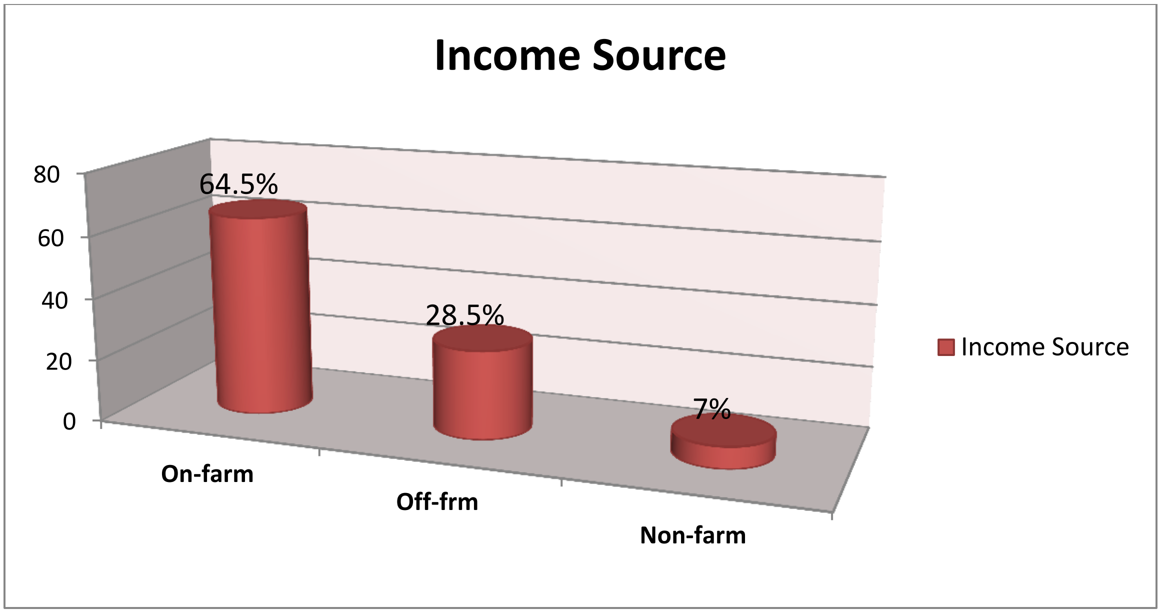

Figure 3 Income source of the respondents

Source: Household survey result in the study area, 2021

4.2 Perception of Farmers on Impacts of Climate Variability

4.2.1 Indicators of Climate Variability

In this study, the sample respondents were asked to identify the intensity of different climate-related problems in the study area. The result showed that, 14.3% of the respondents labeled crop failure as the primary indicator of climate variability in the study area (Figure 4). According to household survey results, 30% and 24.7% of the respondents reported that shortage of rainfall and increment of temperature are the main causes for the crop failure, respectively. Poor livestock productivity, decreased income of agriculture and the increase of flood incidence are also the other climate related problems reported by the respondents. On the other hand, the increase of flood incidence, some loss of plants and animals species and timing of rainfall were chosen by the respondents as the least two indicators of climate variability.

According to FGDs climate change and variability observed in terms of temperature rise, high frequency of recurrent drought and shortage of rainfalls were among the indicators of climate variability in the study area (Figure 4). Unexpected rain during harvesting time and sometimes heavy rainfall accompanied with strong wind was also stated as an indication for climate variability.

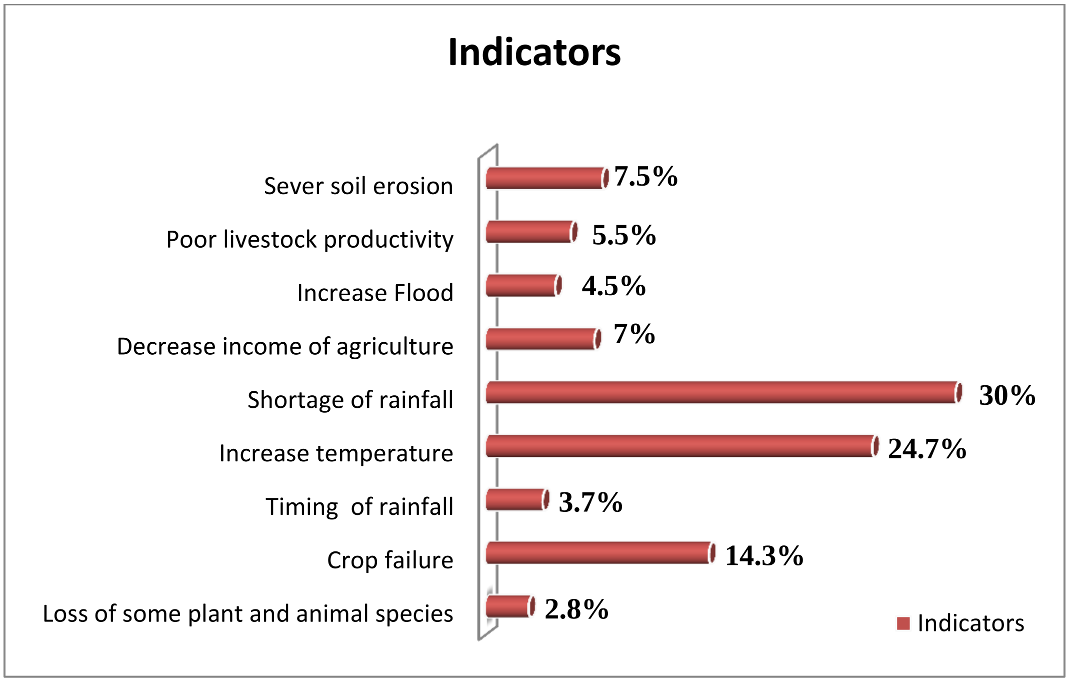

Figure 4 Indicators of climate variability.

Source: Household survey result in the study area, 2021

4.2.2 Perceptions of Farmers on Climate Variables

I. Farmers Perception on Rainfall

Changes in rainfall amount and pattern, affect rate of soil erosion and soil moisture content, both of which are significant for crop yields (IPCC, 2015). Most of the interviewed farmers perceived the existence of rainfall changes in terms of both the amount and distribution over the years (Figure 5). Of the interviewed respondents, 83% felt a decrease in the amount of rainfall. However, 7%, and 10% respondents felt an increase and no change respectively.

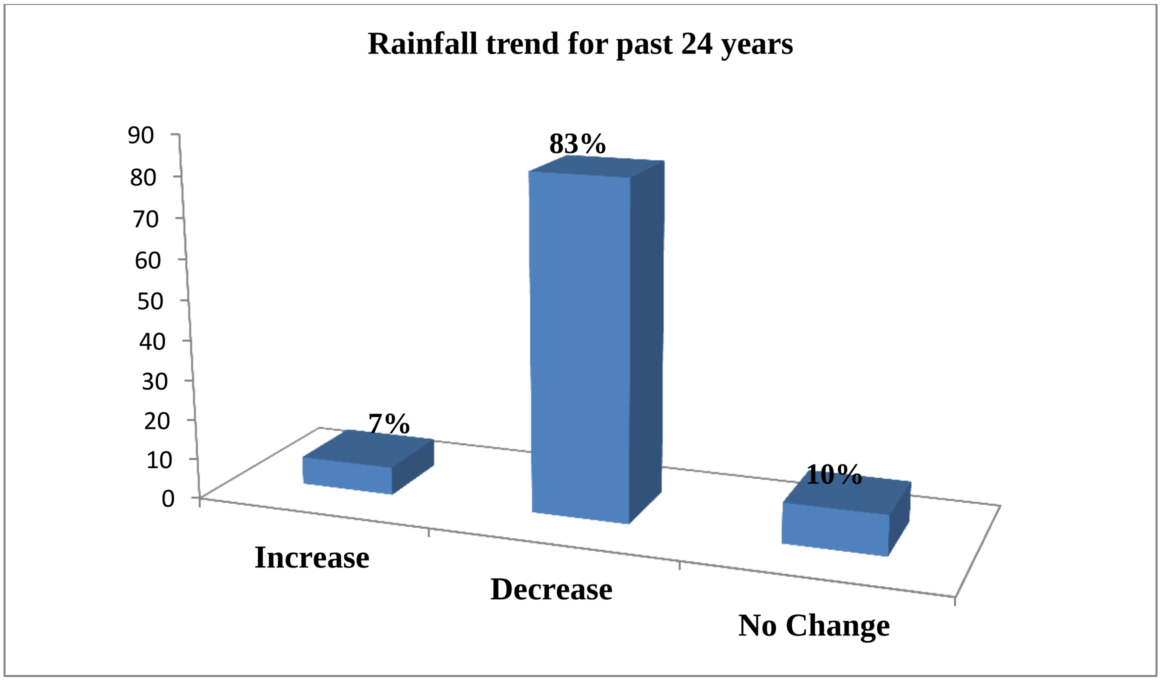

Figure 5 Trend of rainfall in Doyogena Woreda for past 24 years

Source: household survey result in the study area, 2021

II. Farmers Perception on Temperature

The majority of respondents (84.7%) perceived an increase in temperature over the past 24 years (Figure 6). About 2.5% perceived a decreasing in temperature and 12.8% no long-term change in temperature. Similar results were obtained from the focus group discussion. Generally, farmers believe that the increasing temperature trend was associated with the decreasing changes in rainfall. Similarly to this finding the research of respondents feel that temperature of the study area was increasing in the last two decades.

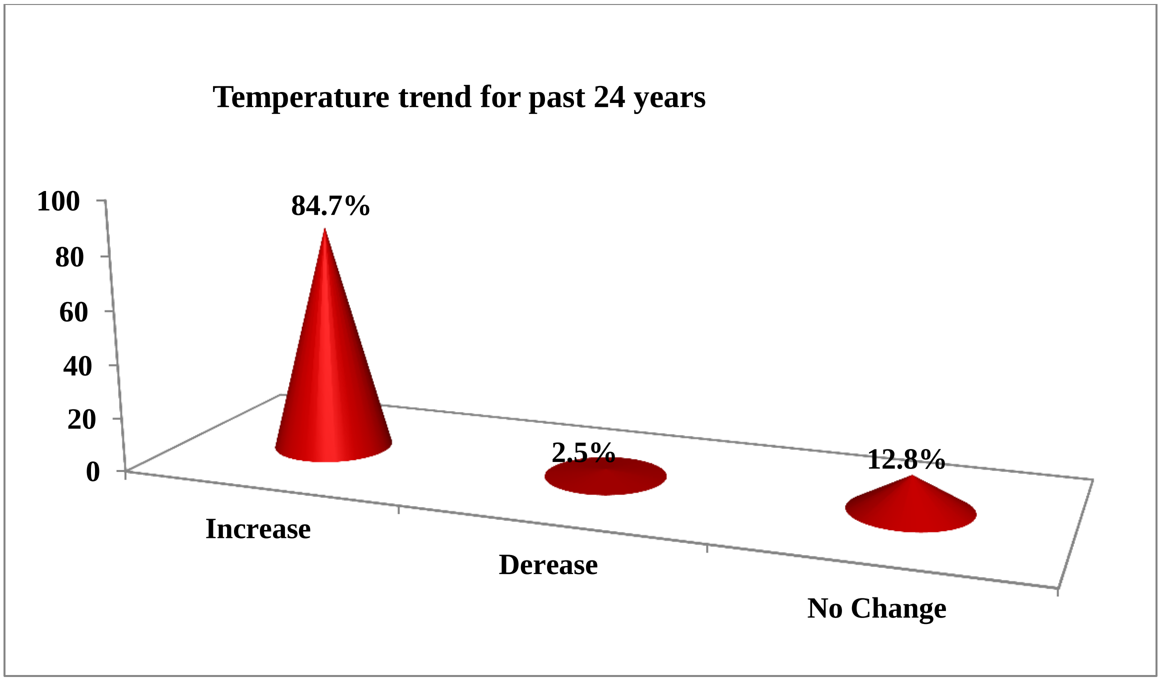

Figure 6 Trends of temperature for the past 24 years

Source: Household survey result in the study area, 2021

III Rainfall trends

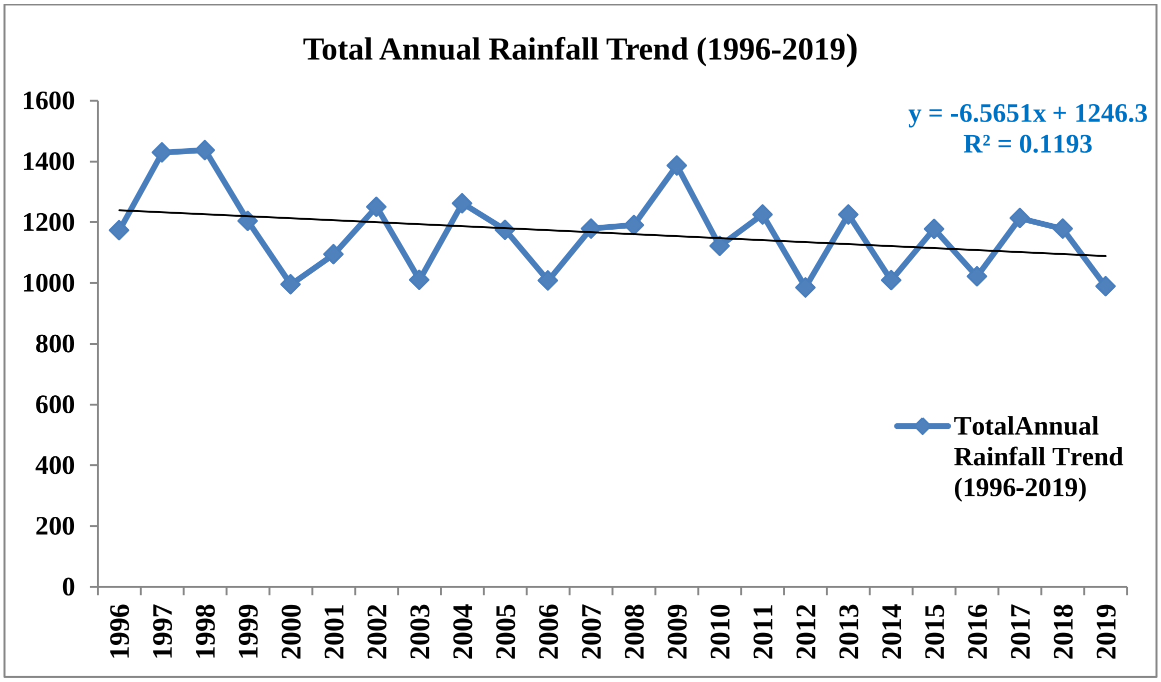

Figure 7 Annual Trend of Rainfall

Source: Computed from RMAS Data (1996-2019)

Seasonal Rainfall Trends

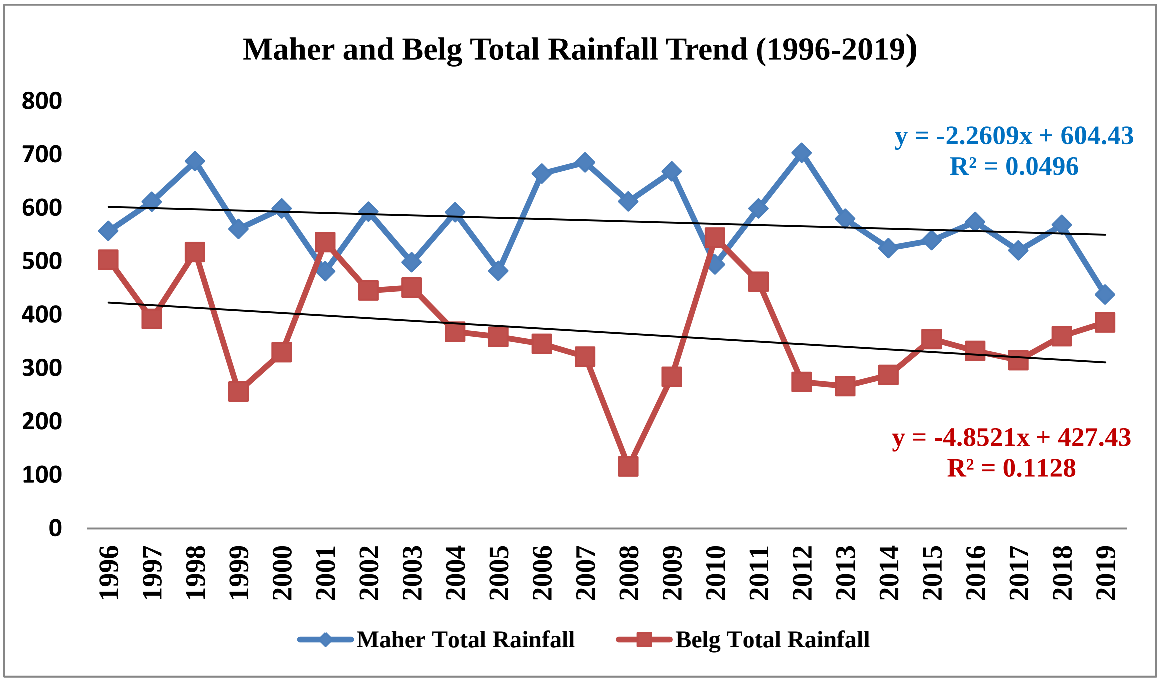

Figure 8 Seasonal Trends of Rainfall

Source: Computed from RMAS Data (199-2019)

The data obtained from Regional Metrological Agency Service revealed that the coefficient of variation of study area were 11.5% and 27.8% for summer (maher) and spring- (belg) respectively. This indicates that there was less variability of rainfall especially during the summer (maher) season, while the belg rainfall variability was moderate revising 1996-2019 (Table 5). However, the problem of the study area was erratic and untimed rainfall that was occurred unexpected flood and prolonged drought.

A study made by (Abate 2009) in which, CV is used to classify the degree of rainfall variability indicated that, CV<20 it is less variable, CV <30 moderate and high CV>30. Various studies indicated that the trends in inter-annual and inter-seasonal rainfall variability was decline in amount and increase in intensity along with increasing temperature which would aggravate the rate of erosion, and consequently reflecting negative implication on crop productivity. The impact of rainfall on crop production can be related to its total seasonal amount or its intra seasonal distribution

Table 5 Annual and Seasonal Rainfall Analysis (1996-2019)

Rainfall (mm)	Minimum (mm)	Maximum (mm)	Mean	Stdv (mm)	CV (%)
Annual	985.3	1429.5	1164.19	134.39	11.5
Summer (maher)	437.4	702.8	570.1	71.75	12.5
Spring (Belg)	115.5	544.1	366.7	102.3	27.8

Source: Computed from RMAS Data (199-2019)

According to Regional Meteorological Agency of Ethiopia (NMA), in the SNNP Region Doyogena Woreda, the seasonal rainfall shows lower inter-annual variability than the belg (small rainy season, February-May) rainfall..

The summer (Maher) rainfall in this study has shown decreasing trend with -2.26 mm per year in the period noted.The spring/belg season rainfall has shown decrease trend from1996-2019 by -4.58 mm per year in the study area despite untimed rainfall and unexpected erosion occurred while droughts frequently exist.

IV Annual Standard Precipitation Index (SPI)

The standardized anomaly of total annual rainfall revealed that, above average rainfall in the area was recorded for 12 years and below average rainfall for 12 years. Based on standard precipitation index procedure, the rainfall period of study area approximately categorized in to two decades (Figure 9). First decade (1996-2007) was relatively wet, while the second (2008-2019) decade drier, confirming the slightly decrease trend already observed in the trend analysis of this study.

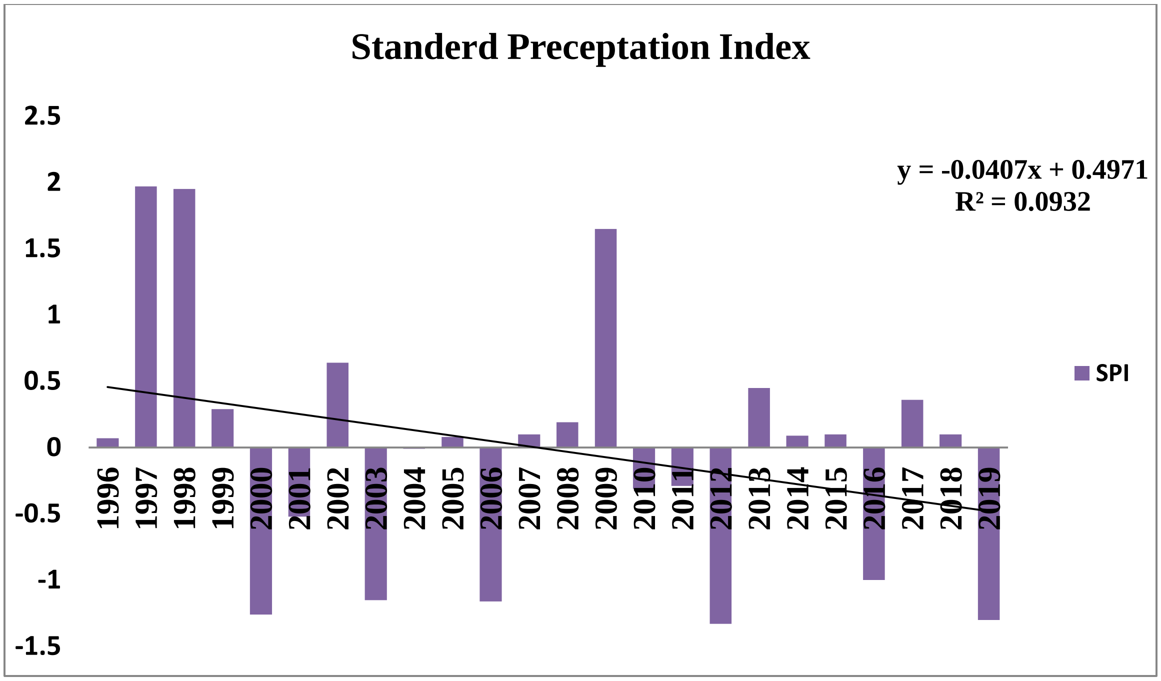

Figure 9 Annual SPI of Doyogena Woreda

Source: Computed from RMAS Data (1996-2019)

V Temperature trends

The trend analysis of annual temperature (minimum and maximum) in the result shows increase in the Doyogena Woreda during the past 24 years.

The mean minimum temperature increased by 0.074ºC per annum during 1996-2019 (Figure 10). The mean maximum temperature increasing by 0.021ºC per annum. (UNDP, 2008) report also revealed an increasing trend of mean annual temperature of Ethiopia by 0.37°C per decade. Similarly, according to (NMA, 2007), the average annual maximum temperature in the country has increased by 0.1°C per in every decade.

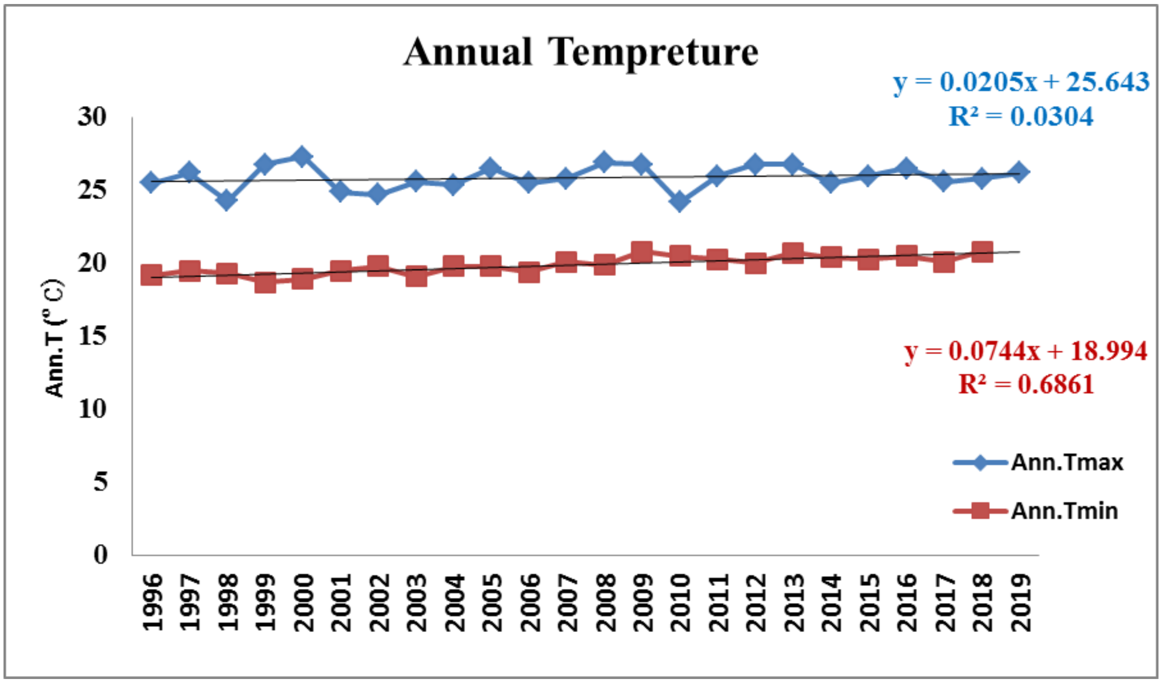

Figure 10 .Annual minimum and maximum temperature trend for 24 years

Source: Computed from RMAS Data (1996-2019)

Generally, the survey result showed that farmers perceived 83% the total and seasonal rainfall trend was decreasing in past two decades, but 7% and 10% increase and no change respectively. The data obtained from Regional Metrological Agency Service revealed that the total rainfall trend was decreasing by -6.56. The coefficient of variation of study area were 11.5% and 27.8% for summer (maher) and spring- (Belg) respectively, which indicates that there was less variability of rainfall especially during the summer (maher) season, while the belg rainfall variability was moderate between 1996-2019 (Table 5).But the problem of the study area was erratic rainfall and untimed rainfall that was occurred unexpected flood and prolonged drought.

The majority of respondents (84.7%) perceived an increase in temperature over the past 24 years (Figure 6). About 2.5% perceived a decreasing in temperature and 12.8% no long-term change in temperature. Similar results were obtained from the focus group discussion. The farmers believe that the increasing temperature trend was associated with the decreasing changes in rainfall. Similarly to this finding the research of respondents feel that temperature of the study area was increasing in the last two decades.

4.2.3 Impacts of Climate Variability on Livelihood

Most farmers follow traditional cultivation practices that rely on seasonal rain water. Erratic rainfall patterns and hailstorm contributing to soil erosion, soil fertility loss, and crop damage are having an adverse impact on livelihoods of most of these communities, thus increasing risk to food security. Climate change and variability have had serious impacts on livestock and crop production in Doyogena woreda recently. Both crop production and animal husbandry were practiced in the area. The livelihood of the people is sensitive to climate change and variability. The main natural constraints to accessing food and generating cash income include drought, pest infestation and livestock disease. According to Doyogen Woreda agricultural development office report, climate change and variability particularly reoccurrence of drought, early cessation and late onset of rain, heavy and unseasoned rain and pests have caused massive croup failure.

As the results shown below, the most commonly mentioned impacts of climate variability were shortage of water (100%), expose to disease (56.5%), shortage of feed of animals (50%), forced to out-migrate (39.5%), famine (54.03%), loss of livestock (11.3%).

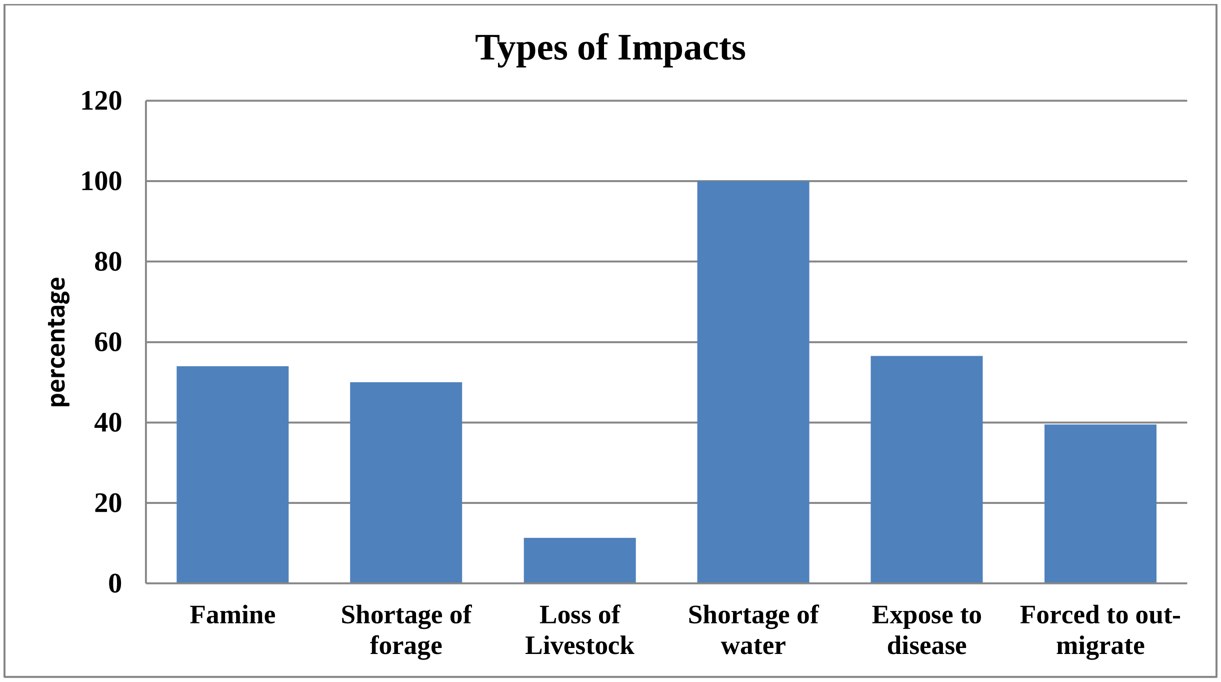

Figure 11 Most commonly mentioned impacts of climate variability (Multiple answers)

Source: Field survey, 2021

The household survey on performance of crop production over the past ten years data shows that there is declining trend in the production and availability of crops in Doyogena woreda. According to (table 6), about 20.9% of the respondents reported that there was better crop productivity before the past ten years. Beside this, 68.5% considered as medium while 10.5% told crop productivity was indicated as poor compared to recent years (2021). The respondents indicated that, 4.03%, 59.7% and 36.3% of the respondents characterized the productivity as good, medium and poor respectively. As researcher noted earlier, climate variability early cessation, late onset, heavy and unseasoned rain and pests were the major reasons for the reduction of crop production. For instance, this variability of rainfall in Doyogena woreda has affected crop production and some impacts on livestock husbandry.

Table 6 Performance of Crop Production over the past 10 Years

How do you see crop production in time		No. of Household	Percentage
Performance of crop production before 10 years ago	High	38	20.96
	Medium	124	68.54
	Low	19	10.5
Performance of crop production in 2021			
	High	7	4.03
	Medium	108	59.67
	Low	66	36.3

Source: Field survey, 2021

According to (table 7) an assessment of livestock possession of the sample households were conducted in the area in the past 10 years. Average ownership of livestock per household shows that the number of domestic animal assets decreased over time. For instance, now/2021 the average number of livestock per household in the study area has declined. This shows a declining trend of animal assets.

Table 7 Domestic Animal possession of Sample Household Heads before 10 years and 2021

Livestock	Before 10 Year total number	Total number in 2021
Ox	262	113
Cow	298	171
Donkey	241	172
Horse	17	3
Sheep	1074	565
Goat	312	78

Source: Field survey, 2021

Generally, the households in Doyogena woreda were facing declining trend of crop and animal production because of variability of rainfall, pests, diseases, and increased and variability's of temperature. As a result, some considerable portions of the households were exposed to reduction of food crops and expansion of disease. They also told that the situation has worsened over time. Shortage of forage is the main reason to decrease their.

4.3. Farmers' Adaptation Strategies to Climate Variability

For this study, adaptations are adjustments or interventions, which take place in order to manage the losses or take advantage of the opportunities presented by a changing climate. It is the process of improving society's ability to cope with changes in climatic conditions across time scales, from short-term to the long-term. The goal of an adaptation measure should then be to increase the capacity of a system to survive external variability.

A number of adaptation options used by famers have been explored. Accordingly, the following adaptation strategies have been identified as a prominent adaptation strategies used in the district. These were identified by considering the number of frequencies of these adaptation strategies among farmers as compared to all other options surveyed. It is found that farmers were using adjustment of planting dates, income source diversification, using drought tolerant varieties, SWC practices, irrigation, crop diversification, and changing livestock variety which accounts the response of 54.19%, 38.71%, 48.39%, 63.22%, 59.35%, 34.19%, and 20.64% sample households, respectively to reduce the negative impact of climate variability (Table 8). The use of SWC practices was the most common response among the seven adaptation strategies. On the contrary, use of agro-forestry was the least used adaptation strategy among the seven strategies. Respondents in the focus group discussion reasoned out that shortage of farmland is the major impediment not to use agro-forestry because large proportion of their land is allotted for production of food crops. In most cases, however, farmers use some adaptation strategies in combination with other adaptation strategies.

Table 8 Summary of Adaptation Strategies Used by Farmers

Adaptation strategies	Number of respondents (n=181)	Percent (%)*
Adjusting planting date	84	54.19
Income diversification	60	38.71
Use of drought tolerant varieties	75	48.39
Soil and water conservation	98	63.22
Use of irrigation	92	59.35
Crop diversification	53	34.19
Changing livestock variety	32	20.64

Source: Own survey, 2021

Note: * Percentages cannot be added to 100 since a farmer can employ more than one adaptation strategy at a time

4.4. Factors Affecting farmer's Adaptation Strategies

The results of MNL model showed that factors affecting farmers' adaptation strategies to climate change and variability adaptation and significant levels of the parameter estimates in the study area shown below in (Table 9). Accordingly, the likelihood ratio statistics as indicated by ch² statistics (LR chi-square (54) = 218.41 are highly significant (P < 001)) suggests that the model has strongly explanatory power. Therefore, (table 8) represents the MNL results along with the level of statically significance.

In this study, multi-colinearity between the independent variables was tested using VIF. It measures the degree to which the interrelatedness of the variable with other predictor variables inflates the variance of the estimated regression coefficient for that variable. That is, as the extent of co-linearity increases, the variance of an estimator increases, and in the limit it can become infinite. On the contrary, if there is no co-linearity between independent variable VIF will be 1 (Gujarati, 2004).

Similarly, the contingency coefficients, which measure the association between dummy variables, were computed in order to check the degree of association among the dummy variables. The values of contingency coefficient ranges between 0 and 1, in which zero indicates no association between the variables and values close to 1 indicates a high degree of association. Accordingly, there was no serious problem of association as the contingency coefficients were not exceeding 0.07.

The coefficients of MNL tell us about the direction of effect of the independent variables on the dependent (response) variable; despite they do not represent actual magnitude of change or probabilities.

Codes of the Variables, Definitions and Units of Measurement

A. Dependent variable

Y1= Crop diversification strategies

Y2= Adjusting planting date

Y3= Irrigation use

Y4= Soil and Water Conservation

Y5= Income source diversification

Y6= Changing Livestock variety

B. Independent variable

- ✓ SEX Sex of household head
- ✓ AGE Age of household head
- ✓ LEDUC Education level of household head
- ✓ FAMSIZE Family Members of Household Head
- ✓ FARMEXP Farming experience of farmers in years
- ✓ FRMLAND Farm Size of the Household Head in hectares
- ✓ MTHLTINC Monthly income of household head

- ✓ LIVOWSHIP Livestock ownership of household head
- ✓ ACEXTSER Access to extention service
- ✓ ACCRSRV Access to credit service

Table 9 Parameter Estimates of Multinomial Logit Model for Climate Change and Variability Adaptation Strategies Conducted in Study Area.

Explanatory Variabiles	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Y6**
	Coeff. (P-value)	Coeff (P-value)	.Coeff. (P-value)	Coeff. (P-value)	Coeff. (P-value)	Coeff. (P-value)
SEX	-1.4034610	1.568755	.0364449	.5689739	.3584542	17.36367
	(0.214)	(0.208)	(0.970)	(0.467)	(0.714)	(0.988)
AGE	-.7651306	1.410335	-2.188099	-.5648238	-.4846985	-.4480106
	(0.157)	**(0.012)****	**(0.040)****	**(**0.215**)**	(0.713)	(0.485)
LEDUC	-1.642688	-.3707495	-.7268436	-.4846384	-.32948160	-.3894784
	(0.005)***	(0.185)	**(0.051)****	**(0.021)****	(0.361)	(0.075)
FAMSIZE	-.0008796	-.0354216	1.153363	2.2303670	.75533430	.1325139
	(0.999)	(0.939)	**(0.051)****	**(0.000)*****	(0.133)	(0.864)
FRMLAND	-.6325019	-.2107334	.4628544	-.2392367	-.5428650	-.2568618
	(0.286)	(0.526)	(0.319)	(0.420)	**(0.018)****	(0.391)
ACEXTSER	-6.261509	.2536802	-1.606016	-.2261105	.070360	.3601405
V	**(0.000)*****	(0.771)	(0.254)	(0.752)	(0.998)	(0.531)
ACCRDTSE	18.36074	17.48265	-1.606016	-.866796	.1549930	-.5406243
RV	(0.989)	(0.995)	(0.117)	**(**0.107**)**	**(0.080)***	(0.367)
FARMEXP	-.4478875	-.4580128	.6739705	-.328131	.8997350	-.2568618
	(0.403)	(0.396)	(0.460)	**(**0.550**)**	(0.548)	(0.360)
LIVOWSHIP	.6512115	.2672747	.0589879	.25466810	.28156140	-.0008796
	(0.224)	(0.513)	(0.912)	(0.591)	(0.574)	(0.999)
MTHLTINC	-1.140437	-1.018812	1.908943	-.20077970	.24401350	-.6325019
	(0.033)**	**(0.061)***	**(0.001)*****	**(**0.552**)**	(0.593)	(0.286)

No_ of observation 181

Prob $>X^2$ 0.0000

Pseudo Rsquare0.3322

Notes: ***, **, * denote significant at 1%, 5% and 10% respectively.

Source: Computed by STATA version 14.1 based on survey result (2021)

Marginal effects from the MNL, which measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable, are reported and discussed. In all cases, the estimated coefficients should be compared with the base category. The marginal effects, along with the levels of statistical significance are also presented below (Table 10).

The marginal effects of marginal probabilities are a function of probabilities and measures expected to change within the probabilities. In the following section, only the variables that were statistically significant at less than or equal to 10% probability levels are interpreted and discussed.

Sex of Household Head: As hypothesized, sex of the household is negatively associated with adaptation strategy of crop diversification. This implies that both sex and adaptation strategies are inversely proportional. In addition, the variable is statistically insignificant at ($P<0.01$) and ($P<0.10$) for all adaptation strategies. This result shows that male-headed sample households were more likely to select and adapt as compared to female-headed households. In other words, the results of this study imply that female farmers showed high interest towards climate variability adaptation practices, yet they invested little and rarely practiced them. It is evident that adaptation strategies are more labor and capital intensive that may be suited to the fewer households with better capacity and male-headed households.

This finding supports results obtained by Temesgen et al. (2010) which argued that sex has negative and significant relation with adaptation strategies. As observed from the result an increase of number of female farmers, decrease probability of adapting strategies by about 53% and 41% respectively.

Age: The age of the household head was one of the statistically significant explanatory variables that have negative and positive coefficient (Table 9). The positive sign indicates that it has a positive influence on taking an adaptation strategy to climate variability. As the age of the household head increases by one year, the probability of household head using mixed crop livestock system as an adaptation strategy to climate variability is increased by 10.4%, at less than (1%) probability significant level, keeping other variables constant. Similarly, as a year increase in the age of the household head, the probability to use adjusting planting date as adaptation strategy increases by 6.3% with the p-value of (<5%), keeping other variables constant. The result also indicates that, as the age of the household head increases by one year the probability of using irrigation adaptation strategy to climate change decrease by 8.5% with the p-value of (<0.05%).

Similarly, as a year increase in the age of the household head, the probability of farmers not use adaptation strategy decrease by 4.2% at less than (1%) significant level, keeping other variables constant.

Family Size: The family size of the household head was a statistically significant explanatory variable in this model, which indicates farmers' adaptation strategy to climate change is also significantly affected by the number of family size. A one-unit increase in the family member resulted in an increase of probability of farmers using soil and water conservation as adaptation strategy increased by 16% at less than (1%) significant, holding other variables constant (Table 9). (Gbetibouo, 2009) also showed that household with larger family size are more willing to choose soil conservation techniques as adaptation measures that are labor-intensive especially in small scale farming. On the other hand the current result indicated that one unit increases in the member of the family resulted in a 5.3% decrease in the probability of farmers implementing mixed crop livestock system as adaptation strategy with the p-value of (<5%). This is in agreement with the study reported by (Belay et al., 2017) study.

Education: The results of this study revealed significant and negative effects of education on soil and water conservation, mixed crop livestock system, irrigation and no adaptation(resistance to accept adaptation) strategies to climate change and variability. However, as the education of household head increases by one level, the probability of adopting planting date adjustment as adaptation strategy increases by 2.1% with the p-value of (<10%), keeping other variables constant. While no adaptation (resistance to accept adaptation) strategies decreases by 4.3% with the p-value of (<5%), keeping other variables constant (Table 9). On the other hand the use of mixed crop livestock system as adaption strategy declines with an increase in education level of the household head. Although, looked this result seems in contrary to the expectation whereby higher level of education to be positively related to adaptation to climate change, it may be associated with the complex nature of the specific strategy to be practiced in modern crop production system.

Farm land size: The farmer's land size had a positive and significant impact on farmers' choice of adaptation methods to climatic change. Accordingly, the results of the current study revealed that, as farm size of household head increases by one hectare, the probability of the farmers to use income diversification by using to non-farm adaptation options significantly increases at (<1%) significant level.

Livestock ownership: is significant explanatory variable in this study. It was positively influencing the farmer's adaptation decision of taking mixed crop livestock system as a climate change adaptation measures. A one unit increase in the number of livestock owned by household, the probability of using mixed crop livestock system as adaptation strategies to climate change and variability also increased by 5.3 % with the p-value of (<5%), keeping other variables constant (Table 9).

Monthly income: monthly income of the household head is also a significant explanatory variable as shown in the (Table 9). The result of this analysis reveals that income of household had a negative and positive significant influence on no adaptation (resistance to accept adaptation) and using irrigation adaptation strategies in response to climate change, respectively. A one percent (ETB) increases monthly income of household, the probability of farmers to use adaptation strategies of irrigation increased by 7.9%. Moreover, a one percent (ETB) increases monthly income of household, the probability of farmers no adaptation (resistance to accept adaptation) strategies decreased by 3.6% with p-value of 0.024, keeping other variables constant.

Table 10 Marginal Effects from the Multinomial Logit model on the Climate Change and Variability Adaptation Strategies.

Explanatory tory Variabiles	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Y6**
	Coeff. (P-value)	Coeff. (P-value)	Coeff. (P-value)	Coeff. (P-value)	Coeff. (P-value)	Coeff. (P-value)
SEX	-.065446	-.0401405	.0961736	-.0015023	.0492153	-.007133
	(0.104)	(0.513)	(0.157)	(0.966)	(0.428)	(0.849)
AGE	-.0424385	.1042483	.0634295	-.0854037	-.05648980	.0121602
	(0.006)* **	**(0.003)*** **	**(0.020)** **	**(0.028)** **	**(0.067)* **	(0.664)
LEDUC	-.0430618	-.0979342	.0216806	-.0147778	.00403550	.0093568
	(0.026) **	**(0.000)*** **	**(0.074)* **	(0.273)	(0.798)	(0.392)
FAMSIZ	-.0151262	-.0537658	-.0215596	.0197537	.16443520	.0446878
E	(0.455)	**(0.049)** **	(0.304)	(0.286)	**(0.000)*** **	**(0.050)** **
FRMLA	-.0183899	-.0347493	-.0012752	.019889	-.01917010	.0378734
ND	(0.403)	(0.132)	(0.936)	(0.238)	(0.377)	**(0.000)*** **
ACEXT	-.2537563	-.0028807	-.0204231	.0111775	-.15034770	.6196739
SERV	(0.527)	(1.000)	(0.998)	(0.999)	(0.995)	(0.995)
ACCRD	.6232141	-.476017	.8840636	-.103877	-.2957667	-.0014629
TSERV	(0.991)	(0.994)	(0.995)	(0.968)	(0.985)	(1.000)
FARME	-.0197507	.0265215	-.0279324	.02564	.0246146	-.0207538
XP	(0.282)	(0.509)	(0.284)	(0.460)	(0.500)	(0.516)
LIVOW	.0149752	.0532063	-.0032614	-.002473	.0067161	-.0237183
SHIP	(0.437)	**(0.031)** **	(0.869)	(0.900)	(0.793)	(0.265)
MTHLT	-.0367241	-.0141428	-.0439451	.0790247	-.01627610	.0150112
INC	**(0.024)** **	(0.602)	(0.132)	**(0.000)*** **	(0.491)	(0.320)

Notes: ***, **, * denote significant at 1%, 5% and 10% probability level respectively.
The values indicate coefficient (P-value).

Source: Computed by STATA version 14.1 based on survey result (2021)

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Climate variability has adversely affected the livelihoods of people in developing countries where a large proportion of the population is heavily dependent on agriculture. Long-term records indicate that there have been severe and repeated rise in temperature and rainfall failures resulting in severe food insecurity, including famines in Ethiopian due to significant loss of crops and livestock. Farmers should thus be able to adapt in order to reduce the negative impact of climate variability in Doyogena district.

This study was conducted to investigate farmers' perception on impact of climate variability and adaptation strategies to climate variability in the study area based on 24 years. The results showed that majority of the farmers are well aware of the increase in temperature and the decrease in rainfall. As per the result of the descriptive statistics, 84.7% and 83% of the respondents perceived the existence of climate variability with its attributes temperature and rainfall, respectively. Thus, most of the farmers perceived the existing impact of climate variability in the study area. However, there are still a significant number of farmers who didn't perceive the change yet and did not perceive the erratic nature of rainfall distribution and variaio of tempreture in the study area.

The data obtained from Regional Metrological Agency Service revealed that the total rainfall trend was decreasing by -6.56. The coefficient of variation of study area was 11.5% and 27.8% for summer (maher) and spring- (Belg) respectively. The data indicates that there was less variability of rainfall especially during the summer (maher) season, while the belg rainfall variability was moderate during 1996-2019. However, the problem of the study area was erratic and untimed rainfall, which was occurred unexpected flood and prolonged drought. The mean minimum temperature increased by 0.074ºC and the mean maximum temperature increasing by 0.021ºC per year.

The most common adaptation options of the farmers in response to impacts of climate change and variability: using improved crop varieties, mixed crop and livestock system, using irrigation, soil and water conservation, adjusting planting date and income diversification activities. According to this study, shortage of rainfall and increment of temperature have been found to be the main causes resulting in; crop failure, Poor livestock productivity, decrease income of agriculture and loss of plant and animal species, as well as severe soil erosion are the most common climate change-related hazards that occurred in the study area.

. The multinomial logistic model used to analyze the relationship between the socio-economic characteristics and farmers' choices of adaptation strategies to climate variability indicated that age, education, family size, monthly income, livestock ownership and farm size had significant effect on farmers' choice of climate variability adaptation strategies.

5.2 Recommendations

Based on the outcomes of the study, the following recommendations are forwarded to local communities and government representatives.

- ✓ Promote increase farmer’s perception on the causes and adaptation on climate variability through training.
- ✓ Improve farmers adaptation capacity introduced and enforced the farmers to use new agricultural technologies.
- ✓ Introduce irrigation technologies to reduce the dependency of rain-fed agriculture and to secure availability of food.
- ✓ Facilitate research and extension services to provide adequate extension information services to ensure that farmers receive up-to date information about rainfall and temperature patterns in the for the coming season so that they can make well informed decisions about their planting dates,
- ✓ Promoting mixed agriculture through improved crop and livestock to diversify livelihood of the farmers in order to resist climate change risk.
- ✓ Promoting sex of the household head being female; and access to climate change and variability information in order to take adaptation mechanisms.

Finally I would like to recommend similar studies to be conducted which adequately address the issue of vulnerability to climate variability, and the relative value of each adaptation option to better knowledge of farmers for adaptation to climate variability and to develop locality specific adaptation strategies, which is able to account for impacts of climate change and variability.

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APPENDICES

HAWASSA UNIVERSITY

COLLEGE OF AGRICULTURE

SCHOOL OF GRADUATE STUDIES PROGRAM OF CLIMATE CHANGE ANDSUSTAINABLE AGRICULTURE

QUESTIONNAIRE FOR HOUSEHOLD HEADS

Appendix 1: Questionnaire

Dear respondents, my name is Mulueta Gebre, a graduate student in Hawassa University and I am conducting a research for the partial fulfillment M.Sc in Climate Change and Sustainable Agriculture. The main objective of this questionnaire is to get firsthand information on **the Farmers' Perception of the Impact of Climate Variability and Adaptation Strategies: the case of Doyogena Woreda, in SNNP Note that:**

- ❖ All responses will be held confidential;
- ❖ Feel free to ask any question you may have about the questionnaire;
- ❖ Your genuine participation by responding patiently to the questionnaire is highly appreciated and thanks you for giving your time and willingness to participate in filling this questionnaire.

Study area Region: Southern Nation Nationalities and Peoples Region Zone: KT, Wereda: Doyogena

<u>Part One</u>: Background Information about Households and Socio economic Conditions Make a Circle given letter

Section A. Interview:

Put(X) marks in box provided for closed ended questions and write your response on space provided for open ended questions.

General Information

Respondent's Name……..…………………………………..……………

Woreda Name……………………………………………….

Name of Kebele (village)…………………………………..…………….

Questions on Household Head Demographic and Socio-economic Characteristics

1) Sex A. Male B. Female

2) Age A. 18-25 B. 26-35 C. 36-45 D. 46-65 E. above 65

3) Marital status A. Married B. Single C. Widowed D. Divorced

4) Educational status A. Illiterate B. Capable to read and write C. Primary school D. Junior E. Secondary School F. Other

5) Family size A. 1-2 B. 3-5 C. 6-9 D. more than 9

6) Farming experience of the respondents (number in year) A. 0 B. 1-5
C. 6-10 D. 11-20 E. 21-30 F. more than 30

7. What is your main source of income? A. on farm B. off farm C. non-farm

8. What is the size of your land? **_______** (hectare) A. 0.5-1 B.1.01-1.5 C. 1.51-2

D. more than 2

<u>Part Two</u>: Livelihoods of the Household

1) Source of income for you the household? (Multiple answers can be possible) A. Crop

production B. Cattle rearing C. pottery D. Carpeting E. Daily laborer F. Trade G.

Other (specify)**_______**

2) If your answer is "crop production" what are the main factors that adversely affect it?

(Multiple answers could be given) A. Irregularity of Rain B. Temperature fluctuation

C. Crop disease D. Luck of agricultural inputs E. Farming method

3) Do you have your own farm land? A. Yes B. No

4) If your answer for Q 3 is „yes', how much hectar**e-----------------**

5) Do you have livestock? A) Yes B) No

6) For above question if your response is "yes" how many livestock do you own

Animals Type	Number of animals at Present	Before 10 Years Ago
Ox		
Cow		
Sheep		
Goat		
Donkey		
Horse		
Mule		
Other		

7) Do you have non-farm or of farm income sources? 1. Yes 2. No

8) If yes mention______________________

9) When did you start this work?

10) Why you are doing this work? A. To get a better income B. Income yield from agriculture is few. C. It is a trained inherited from family D. To pay a credit E. Shortage of farm land other (specify) ---------------------------------

11) For how many time you have been here?

12) Did you make a change to the crop type that you cultivate before? A. Yes B. No

13) If yes what did you cultivate before? --------------------------Now? --------------------------

<u>Part Three</u>. About Climate Variability

1) Have you heard of the word "Climate Variability" before? A. Yes B. No

2) Do you understand what "climate Variability" means? A. Yes B. No

3) If your response is "Yes" from which source you hear? A. Television B. School C. Radio D. Newspaper E. Government agencies F. NGO

4) What is your perception on climate condition of your woreda? A. There is climate

variability

B. The climate has totally changed C. The climate has not change About Climat Variability

5. What are the indicators for the change or variability?

A. Shortage of annual rainfall
B. Changing of temperature
C. Decrease income of agriculture
D. Poor livestock productivity
E. Sever Soil erosion
F. others (Specify)………………...

6. Which local indicator do you use to evaluate today's rainfall pattern?

A. Loss of some plant and animal species
B. Rainfall comes early or lately
C. Increased drought and flood frequency
D. Decline of agriculture yields
E. Decreased surface water
F. Other (Specify)……………………..

7. How was the trend of rainfall for the past 24 years to date according your perception?

A. Increasing B. Decreasing C. No change

8. Do you feel that timing of rainfall is a problem? A. Yes, it starts late and ends up late

B. Yes, it starts early and ends up early

C. No, there is no problem on timing of rainfall but on its amount

D. Yes, it starts on time but ends up early

E. Yes, it starts late and ends up early

9. How is the trend of temperature for the past 24 years according to your perception? A. Increasing B. Decreasing C. No change

10. What is the main impact of climate changes and variability on the local community?

A. Crop failure B. Flooding C. Human disease outbreaks, D. Livestock disease

Institutional Information

11. Do you have extension contact with kebeles development agents?

A. Yes B. No

12. How many contacts did you have during the last production season?

A. Once a week C. Once a month

B. Twice a week D. Twice a month

13. Have you got training from kebeles development agent?

A. Yes B. No

14. If your answer for question #13 is "Yes", in which area of your activity have taken the training?

A. about adoption of new technology in farm activities

B.Information about rainfall distribution in order to give early warning

C.about climate change impact and how it can be cope up

D. about crop (variety) diversification to reduce the risk of climate change

E.Others (Specify)……………………………………………………………

Part IV Assessment of the impact of climate variability induced-hazards

15. Are there any climate variability induced serious impact in the past 10 years? A. Yes B. No

16. If your answer is yes on question number" 22" what are the impacts of climate change induced hazards? (Multiple answers is possible).

A. Expose to disease

B. Land degradation

C. Loss of livestock

D. Shortage of water

E. Shortage of feed of animal

F. Loss of Agricultural productivity

G. list if there is another impact

17. What are the major hazards affecting the livelihood in your locality? Please rank them based on their severity. Rank 1____________, rank 2_____________and Rank 3______________

A. Drought B. extreme heat C. livestock diseases D. Human diseases E. flood F. pests and herb infestations G. shortage of water H. other (specify)

18. What about change in forest cover in your area? A. Increased B. Deceased C. No change

19. How do you see about problem of soil erosion over time? A. Increased B. Decreased C. No change

20. Is there change in water availability? A. Increased B. Decreased C. No change.

21. from your family member who participates to fetch water and collect firewood? (Multiple answers are possible).

A. Female adult C. Male children E. Women

B. Male adult D. Female children

22. Have you experienced with the following types of climate change and variability indicators? A. Yes B. No

23. If your response is yes, number "22" how often (in past decade)

A. Drought B. Flood C. Too-much rainfall D. Too-little rainfall E. Higher temperature F. Frost G.High winds

I. Other (Specify)..

Questions on Adaptation Strategies to Climate Variability

24. In response to climate variability, have you taken any adaptation measures in order to buffer the effects of climate variability? a) Yes b) No

25. If yes to question no.a, have you employed any of the following climate variability?

Adaptation strategies in your farm over the past two decades? Put"x" in ranking order

Adaptation Strategies	Mark "X" on your choice				Rank
	High	Medium	Low	No	
Use of drought tolerant varieties					
Practicing crop diversification					
Integrated farming system					
Increased use of irrigation					
Soil and conservations practices					
Practicing crop rotation					
Income diversification					

Farmer's perception on climate change and variability.

26. Do you perceive climate variability and change? _______________A. yes B. No

27. Is the amount of rainfall increase? A. yes B. No C. constant

28. Is the temperature increase? A. yes B. No C. constant

29. Is rain starting late than normal? A. yes B. No C. constant

230. Is the amount of precipitation sufficient for full cropping during short rainfall?

A. yes B. No C. constant

31. is day and night temperatures changed? A. yes B. No C. constant

Section B. Focus Group discussions

1. What do you understand by the term climate variability?
2. What climate variability impacts do you face in your village?
3. How is the trend of rainfall in the past 10 years in the district?
4. How is the trend of temperature in the past 10 years in the district?
5. Which important crops have disappeared in the last 10 years in your village due to climate change?
6. How and where do you get information concerning climate change and variability?
7. How do you communicate information on climate change and variability?

8. What measures/precautions do you take to combat climate variability impact in your village?

9. How can you relate climate variaiblity impacts to maize production in your village?

10. What causes the impacts of climate variability in your district?

Section C. Key Informant Interview

1. How long have you been in this village/district? ______________________ Years?

2. What are the general conditions of agricultural production in the district for the past 10 years? ____

3. What can you comment on climate change and variability situation in the district for the past 1-10 years____

4. What is the situation of rainfall in the district for the last 10 years?

____

5. What is the situation of temperature in the district for the last 10 years?

____

6. Have you encountered any climate change and variable impacts to maize production in the district?

(Yes/No)____

7. What measures do you take to overcome climate change and variability impacts?

____

8. Do you get any early warning information on the climate change and variability in district?

____

9. Where do you get this information?____

10. What is your role as a community member when climate change and variability impacts threaten maize production in the district? ________________________________

Section D. Agriculture and Rural Development Office officials, DAs and other Experts

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

2. What is the agro-ecology of your zone/district/peasant association?

3. Is there any form of climate Variability in your zone or district? If your answer is yes, please can you explain?

4. If the answer to Q2 is yes, please would you like to explain the extent of climate change and variability impact on wheat crop production and livestock of your zone/district/peasant association?

5. What is the impact of climate change and variability on the livelihood of the people there?

6. Who is more vulnerable to the impacts? Why?

7. What are the local coping mechanisms used to reduce the impacts?

8. What is the institutions effort to reduce future impacts?

9. What are the main challenges and how do you think they can be improved?

Appendix 2: Monthly and annual rainfall data of Doyogena distric

Year	Jan	Feb.	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Ann. Total RF
1996	90.7	17.8	152	170.4	162.7	115.1	186.7	129.3	125.6	6.6	16.3	0	1173.2
1997	22.1	0	84.3	177.6	130.1	171.7	113.1	186.4	140.2	318.7	85.3	0	1429.5
1998	73.8	53.2	107.7	203.6	143	160.2	205.3	NA	133.9	158.5	0	0	1427.1
1999	51	50	56.5	177	122.5	143.5	181.7	107.8	127.7	185.9	0	0	1203.6
2000	0	0	15.4	205.8	108.2	145.5	86.2	124.5	177.9	64.9	21	45.5	994.9
2001	4.8	70.2	184	109.6	NA	91.6	153.2	134.6	101.8	61.9	4.7	5.5	1094
2002	83.2	47.2	150.7	111.7	135.5	90	103.6	244.7	154.7	2.8	0.4	126.4	1250.9
2003	35.8	58.9	118.9	194.4	78.7	108.3	135.9	70.7	182.9	11.7	13.5	0	1009.7
2004	96.8	19.4	90.6	176.2	82	123.4	133.6	152.3	182.1	74.8	17.3	14	1162.5
2005	31.5	18.8	177.8	162.1	197.2	64.6	160.1	94.9	162.6	37.7	67.7	0	1175
2006	28.9	53.9	131.5	160	75.8	159.8	103.9	122.4	88	NA	6	27.2	1007.7
2007	31.8	50.7	118.7	152.1	121.3	163.1	179.9	132.2	210.1	19	0	0	1178.9
2008	0	1.2	43	71.3	218.9	144.6	192.9	136	138.6	126.1	117.5	0.5	1190.6
2009	93.1	54.8	73.4	85.5	120.1	123.5	188.5	181.3	174.7	169.4	105.1	17.1	1386.5
2010	11.8	110	139.9	111.3	182.9	94.4	116	145	138.5	18.9	19.3	33.7	1121.7
2011	15.5	11.2	101.7	115.9	232.8	122.3	163.8	NA	119.3	0	NA	0	1125.2
2012	0	0	67.4	138.3	NA	150.3	233.1	155.9	163.5	1.4	0	7.1	985.3
2013	76.5	51.9	18.9	141.7	148.2	153.7	NA	167.9	133.5	NA	61.2	50.6	1225.6
2014	19.5	0	83.7	118.9	124.3	170.5	134.3	143.2	115.9	23.5	54.2	20.7	1008.7
2015	17.3	57.5	82.1	167	97.9	137.7	164	153.3	134.2	36.4	113.3	17.1	1177.8
2016	43	41.3	65.7	142.9	82.3	93.1	123.9	207.4	149.3	57.2	15.3	0	1021.4
2017	24.1	60	78.3	142	144.6	132.9	175.5	149.4	152.3	84.9	67.9	1.3	1213.2
2018	23.8	0	80.6	125.6	198.3	137.7	145.3	164.1	120.9	105.6	21.4	55.3	1178.6
2019	21.4	49.8	83.1	102.5	132.2	137.3	144.5	126.2	108.5	78.3	0	5.2	989
Mean Monthly	37.2	36.6	96	144.3	136.7	135.6	152.19	150.2	143.1	79.5	35	17.8	1146.19

- **NA.................................. Data not Available**

Appendix 3: Monthly and Annual Mean Max and Min. Temperature of Doyogena District

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Au	Sept	Oct	Nov	Dec	Mean Annual	Max	Min
1996	22.5	25.5	23.9	22.9	22.2	19.8	19.4	19.2	20.9	22.6	23.6	23.9	22.2	25.5	19.2
1997	24	25.9	26.2	22.5	23.4	21.3	19.5	20.4	22.5	22.2	22.3	23.7	22.8	26.2	19.5
1998	23.6	24.1	24.3	24.3	23.1	21.1	19.3	19.5	21.5	21.5	23.1	23.8	22.4	24.3	19.3
1999	24.6	26.8	23.5	25.5	23.5	21	18.7	19.7	21.3	20.9	22.6	24	22.6	26.8	18.7
2000	25.1	26.2	27.3	24.1	22.7	20.9	19.3	18.9	20.9	21.8	22.9	23.2	22.7	27.3	18.9
2001	23.4	24.9	22.9	24.1	21.7	19.9	19.5	19.8	21.8	22.3	NA	24.1	22.3	24.9	19.5
2002	23.1	24.7	23.4	23.9	22.9	20.8	20.7	19.8	21.6	23.8	24.6	24.4	22.8	24.7	19.8
2003	23.4	25.6	25.1	23.4	24.9	21.6	19.1	19.3	21.1	23	23.8	23.6	22.8	25.6	19.1
2004	24.1	24.1	25.4	22.5	23.5	20.5	19.8	20.2	21.4	21.8	23.7	NA	22.5	25.4	19.8
2005	24	26.5	24.6	24	22.2	21.4	19.8	20.8	21.2	22.5	23.1	24	22.8	26.5	19.8
2006	24.8	25.5	23.9	22.9	23.7	21.7	20.7	19.4	NA	23	23.8	23.4	22.8	25.5	19.4
2007	24.5	24.5	25.8	24.1	23.5	20.8	20.3	20.1	21.1	22.7	23.7	24.2	22.9	25.8	20.1
2008	22.5	25.5	NA	24.9	22.7	21	19.9	19.9	20.9	22.5	22.3	23.8	22.7	26.9	19.9
2009	23.9	25.1	26.8	24.5	25	23.3	20.9	20.8	22.2	23	24.6	23.6	23.6	26.8	20.8
2010	24.2	23.3	23.8	23.8	23.3	22.5	21.1	20.5	21.6	22.9	NA	23.9	22.9	24.2	20.5
2011	24.9	25	23.5	26	NA	21.7	21.2	20.3	NA	23.8	23.9	24.2	23.2	26	20.3
2012	25.7	26.8	26.7	23	24.6	22.1	20	20.3	21.1	23.4	23.8	24.3	23.4	26.8	20
2013	24.9	25.6	NA	24	22.7	20.8	20.7	20.8	20.9	NA	23.1	24	23.1	26.8	20.7
2014	24.8	25.5	25.5	23.9	23.5	20.9	20.7	20.4	21.6	23.8	23.6	24.2	23.2	25.5	20.4
2015	24.2	25	25.8	26	NA	21.7	20.9	20.3	21.5	22.7	23.9	24.1	23.3	26	20.3
2016	23.9	26.5	24.3	25.5	23.5	21.3	21.1	20.5	21.4	22.3	NA	24.4	23.1	26.5	20.5
2017	24.6	25.6	24.6	25.5	23.3	22.5	21.2	NA	21.2	21.8	22.9	23.9	23.1	25.6	20.1
2018	25.7	24.9	25.8	23.8	24.6	21.3	21.2	20.8	21.3	22.7	23.2	23.2	NA	25.8	20.8
2019	24.8	25	26.2	25.5	23.7	21.1	20	20.3	22.5	22.9	24.6	24.1	23.3	26.2	20
Mean Monthly	24.2	25.3	25.1	24.1	23.3	21.2	20.2	20.0	21.3	22.6	23.4	23.9	22.9		

- **NA.................................. Data not Available**

BIOGRAPHICAL SKETCH

The author was born in 1986 in Begedamo-Geteme, Doyogena District, and Kambata-Tambaro Zone of SNNP Region of Ethiopia. He attended his elementary education at Hawora-Arara elementary School. He also attended his secondary and preparatory education at Angacha preparatory and Senior Secondary School. After successful completion of his preparatory school education, he joined Wolaita Sodo University in 2012 and graduated with BSc degree in Natural Rrsource Management in June 2014 with distinction. After his graduation, he joined Kambata Tambaro Zone Doyogena Woreda in Agriculture and Rural Development Office, Land Adimnsitration and Use expert and served from 2015 to 2020. During this time he got the chance to work with different governmental organizations serving as a focal person, Supervisor and projects coordinator at woreda level. After five years he joined Hawassa University in 2020 to pursue his MSc degree in Climate Change Sustainable Agriculture.