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Climate Variability and Change Trends, and Factors Affecting Farmers' Adoption of Climate Change Adaptation Methods in Liban Jawi Woreda, West Shoa Zone, Oromia, Ethiopia

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Abstract
This study examined both the tendency of environmental condition variability, especially of precipitation and temperature variability, and determinants of farmers’ adaptation activity in response to the perceived impacts of climate change. To achieve this objective, the stratified random sampling method was used to choose 4 kebeles among 15 kebeles in the Liban Jawi district by classifying kebeles based on agroecological zone as highland, lowland, and mid-highland. The stratified random sampling method was used to choose 312 household heads in the district. Additionally, monthly precipitation and temperature meteorological data (1991 - 2023) were gathered from the National Meteorology Agency of Ethiopia. The outcome indicated that nearly 55.7% of household heads confirmed an increase in annual precipitation, and 80% of household heads detected an increase in temperature in the district. The Mann–Kendall tendency test confirmed that yearly precipitation had increased (Zc=16.35) and was statistically significant at p=0.05 since he calculated the p-value to be 0.0025 < 0.05 for the period of analysis. On the other hand, the Mann–Kendall trend test showed the maximum yearly temperature was increased (Zc=1.52) during the period of analysis, but it is not significant at [Zs] > 1.96 (0.05), which also supports farmers' perceptions. To trim down the perceived impacts of climate change, the household head practiced various farm-level adaptation practices. A multivariate regression model and Spearman correlation matrix were used to examine adaptation selection against a set of socio-economic, organizational, infrastructural, and demographic characteristics of the respondents. The majority of household heads in the study area practiced mixed farming (50%) and water conservation (21%), and adopting drought-tolerant and early-maturing crop varieties (17.01%), agroforestry practices and using weather information and forecasting were among the dominant adaptation practices, respectively, whereas the gender of the household head, education level, extension contact, access to credit, on/off farm income, family size, agroecology, government policy, land size, farm experience and climate information were determinants of adaptation practices in the Liban Jawi district. The outcome of this study provides baseline information for national and local governments, concerned researchers, higher officials and decision-makers in terms of communities' conceptualization of climate variability and change and adaptation practices. To overcome the impacts of climate change and variability, the government and cooperative unions should improve access to varieties and other agricultural inputs.

Keywords: *Climate Variability, Adaptation Strategy, Perception.*

I. INTRODUCTION

➢ *Background of the Study*

According to the IPCC (2012) and Salinger (2009), the Earth's climate system is dynamic, constantly undergoing fluctuations on various temporal and spatial scales. These natural fluctuations are often referred to as climate variability, encompassing phenomena such as seasonal changes, interannual variations (El Niño), and decadal oscillations. While climate variability has always been a characteristic of our planet, enabling life to adjust to changing conditions, the term 'climate change' refers to a fundamental and continual alteration in the weather and climate, typically over decades or longer (IPCC, 2013). This distinction is vital, as climate change signifies a directional trend or shift in the overall climate system, moving beyond the natural range of variability (Fiveable, n.d.; ResearchGate, n.d.).

The Intergovernmental Panel on Climate Change (IPCC) extensively synthesized a growing body of research and technology, unequivocally showing that the present-day climate change is mostly driven by anthropogenic activities (IPCC, 2013, 2021). In postindustrial change, burning and using nonrenewable resources like fossil fuels, deforestation, and certain agricultural and industrial practices have substantially increased the concentration of greenhouse gases (GHGs), like methane (CH_4), nitrous oxide (N_2O), and carbon dioxide (CO_2) (IPCC, 2021; UNFCCC, n.d.). GHG increases due to human-caused emissions trap heat in the atmosphere because energy radiated from the surface becomes trapped in the atmosphere, unable to escape the planet, and this energy returns to the surface and is reabsorbed, leading to global warming, which is a key aspect of climate change (Wikipedia, n.d. a).

The observed effects of this anthropogenic environmental condition alteration, like climate change, are already widespread and increasingly severe, affecting various global systems (IPCC, 2022). These impacts include increasing worldwide air and water body temperatures, increasing sea levels, a general decrease of snow and ice cover, and changes in atmospheric and ocean circulation patterns that influence regional weather (IPCC, 2021). As of the IPCC (2022), heatwaves, heavy precipitation, droughts, and wildfires, which pose significant risks to human societies and natural ecosystems, particularly small island states and developing nations, face amplified challenges in adapting to these changes due to their limited resources and heightened exposure to climate hazards, and were increasing in many parts of the world (Falcam, 2001; PMC, n.d.).

Understanding both climate fluctuations and the overarching trend of climate change is fundamental for effective climate policy and adaptation strategies. While natural variability can sometimes mask or amplify the climate shifts and their implications on long and shorter timescales, robust scientific assessments, such as those provided by the IPCC, distinguish between these phenomena and attribute the predominant long-term warming to human influences (Fiveable, n.d.; ResearchGate, n.d.). International efforts, notably under the United Nations Framework Convention on Climate Change (UNFCCC), recognize the urgent need for both mitigation (reducing GHG emissions) and adaptation (adjusting to the impacts of climate change) to address this global challenge (UNFCCC, 1992).

Adaptation is much more important for the group of developing countries for the immediate term than mitigation; however, mitigation involves human interventions to reduce sources of greenhouse gases or enhance their removal from the atmosphere and tackle the causes of climate change and offers a long-run solution (IPCC, 2001). Because developing countries' smallholder farmers have low capacity to adapt to climate change, as they have relatively low income and education, insufficient technical assistance, value chain to market, and credit, and mostly depend on others for living (Morton, 2007; Harvey et al., 2014).

Another factor is that smallholder farmers in most regions live in remote parts of their country where farmland is susceptible to the impact of extreme weather events that can cause land degradation, landslides, floods, and droughts. This marginal area most of the time lacks/has low access to most of the infrastructure and support from the government (Harvey et al., 2014).

While many smallholder farmers in Ethiopia experienced and responded to adverse weather, most are not adequately equipped for the increased relative frequency and magnitude of extreme climate events anticipated with climate change. This poses a significant development challenge for Ethiopia. Climate change is projected to have severe environmental, economic, and social consequences, particularly for the country's rural farmers, who, to a great extent, rely on natural resources and rainfall for their livelihoods. Agriculture, primarily small-scale farming, is vital to Ethiopia's economy, accounting for 42% of its GDP and supporting 85% of its employment (FDRE 2011).

Small-scale subsistence farmers' agricultural production in Ethiopia is mainly rain-fed and thus extremely affected by climate variability and extremes. 38% of Ethiopia's economic growth potential was affected by current rainfall variability (WB, 2006). According to information from NMA (2007), frequent drought, shortened growing seasons, and the incidence of pests and diseases are among the predicted impacts of climate change on Ethiopia’s agriculture and particularly on small-scale farmers.

According to McSweeney (2008), in addition to socioeconomic challenges, including endemic poverty, limited access to credit and access to markets, environmental degradation, complex disasters, and conflicts, Ethiopia has a complex climate system. Consequently, its effect on countries' economies will likely be sector-specific vulnerability and the macroeconomy. The current government of Ethiopia has acknowledged the top priority of the agriculture sector and takes different initiatives to increase productivity. As climate data shows, temperature increased by 1.3°C (1960-2006), which indicates a mean rate of 0.28°C per decade, where they report a 0.37°C increase for the yearly minimum temperature for every decade (1951-2006) (NMA, 2006), but rainfall stays fairly unflactuating when averaged over the country (Schneider et al., 2008). Similarly, no statistically significant trend in mean annual rainfall was observed in any season from 1960 to 2006 (NMA 2006). However, the spatial and temporal variability of precipitation is high; thus, large-scale trends do not necessarily reflect local conditions. Projecting into the future, most global climate models show some increment in precipitation in some dry and wet seasons in Ethiopia (NMA 2006).

In order to take appropriate mitigation measures for climate variability and change and withstand its impact on agriculture and increase resilience where it was lost, it should be better understood (Thornton et al., 2008). To develop the best climate change adaptation strategy at the community and farm level, knowing and well understanding the nature of impacts, key exposure, and indigenous adaptive responses at local and national institutional levels is crucial.

According to Oxfam International (2010) and NMA (2006), rainfall variability and associated drought and flood disasters are expected to be exacerbated by climate change. So, smallholder farmers should give due attention to adaptation options to enable life to continue, which can be the awareness of the risks of climate change and their capacity to adapt to climate change, and how adaptation can be cautiously designed and enforced to avoid the possibility of maladaptation (FAO, 2007). Therefore, this study analyzed trends of observed rainfall and temperature variability and adoption and adaptation strategies based on the variability between 1991 and 2023.

- *Statements of the Problem*

As many research and reports show alterations in the variability and tendency of rainfall in Ethiopia, they are not consistent and clear. According to Enyew & Steeneveld (2014), Ethiopia, due to its geographical location and particularly being in an equatorial placement and having different topography, has national (even regional) rainfall variability studies that mask zonal-scale variability, as it is a large country in size, more than three times bigger than Germany.

In sub-Saharan Africa, an increasingly changing climate over time is a major obstacle to sustainable development, which is expected to be most vulnerable because Africa mostly depends on natural resources, which are climate-sensitive resources and have low adaptive capacity to change in climate change (Kpadonou et al., 2012). Over the years, the frequency of the climate variation, particularly of precipitation and temperature, has been increasing. (Chibinga et al., 2012). In Ethiopia, climatic hazards caused by rainfall variability cause recurring droughts and floods, severely impacting agricultural output and compromising food security (Berihu, T.; Chen, W.; Wang, L. 2024).

Most climatic variables, like temperature, precipita tion, weather conditions, and sun intensity, mainly characterise the climate systems and determine the seasons (Kamal, Chowdhury et al., 2012). Seasonal migration of the ITCZ and other atmospheric circulation and complex topography are major factors controlling the climate of Ethiopia (Massiliano et al., 2015). The main reasons for variation are landscape-like topography and different latitudes of the places, which lead to variation over space and time. Ethiopia's mean annual rainfall varies significantly across regions, ranging from approximately 2000 mm in the southwestern highlands to about 300 mm in the southeastern and northwestern lowlands. This marked variability underpins the classification of Ethiopia's climate into three distinct seasons: the dry season (Bega) from October to January, the short rainy season (Belg) from February to May, and the main rainy season (Kiremt) from June to September (Conway & Schipper, 2011).

Different spatio-temporal scale studies show the variation of rainfall in the country. According to the study of Seifu and Abdul Karim (2006) and Osman and Sauerborn (2002), in most parts of the country, there is no fundamental tendency of belg precipitation, while summer precipitation shows a momentous diminishing tendency. On the other hand, there is a clearly decreasing trend of yearly and summer precipitation, which started in the late 1910s and continued with a progressive descending trend. Recent climatic observations reveal contrasting rainfall trends across Ethiopia. While annual rainfall has shown an increasing trend in central regions, a decline has been recorded in the northern and southwestern parts of the country. Specifically, Kiremt and total annual rainfall are decreasing in the northern, northwestern, and western areas, whereas a slight upward trend in annual precipitation is noted in some eastern regions (Negash et al., 2013).

Numerous studies (e.g., Osman et al., 2002; Hagos et al., 2009) have explored the economic impacts of rainfall variability, concluding that it can lead to up to a 20% reduction in agricultural output and a 25% rise in poverty, ultimately costing Ethiopia more than one-third of its potential economic growth (Admassie et al., 2010). This highlights how fluctuations in rainfall can severely affect both production levels and livelihoods.

Temperature and precipitation are widely recognised as key indicators in climate science and hydrology, frequently used to assess the scale and progression of climate change (IPCC, 2007). According to Cheung et al. (2008), in economies like Ethiopia's, which are largely dependent on low-yield, rainfed agriculture, variability in rainfall is a major driver of food insecurity and socioeconomic vulnerability.

Given these conditions, analysing the spatial and temporal variations in climate variables is essential for informing evidence-based policy and decision-making. In the study area, fluctuations in seasonal and annual rainfall and temperature have contributed to climate extremes. Local communities report perceivable increases in temperature and shifts in the onset and end of rainy seasons, posing challenges to effective agricultural planning. However, there remains a lack of district-level research that quantitatively examines rainfall and temperature variability. This study aims to address that gap by analysing local patterns in rainfall frequency and their implications.

Temperature and precipitation are among the most critical variables in climate science and hydrology, commonly used to assess the scale and intensity of climate change and variability (IPCC, 2007). According to Cheung et al. (2008), in countries where the economy heavily relies on low-yield, rainfed agriculture, fluctuations in rainfall patterns are often key contributors to socioeconomic challenges, including food insecurity. As a result, investigating the spatio-temporal dynamics of these meteorological variables is very crucial so as to provide input for policymakers and practitioners that helps to make informed decisions. In the study area, variation of seasonal and annual temperature and rainfall can be a case of climatic extremes. Local communities have perceived an increase in temperature from time to time. The change in the onset and offset of the rainy season is challenging for local farmers to undertake agricultural production. But there was no research-based finding on the trends of rainfall and temperature variability at a district level with its implications. Therefore, this study was conducted to fill the gap at the district level based on the variability of rainfall frequency in the study area.

➢ *Research Questions*

The main research questions are as follows:

- What does the climate variability, particularly in the temperature and rainfall trends, indicate from 1991 to 2023 in the Liban Jawi district?
- What are the perceptions of smallholder farmers about the impact of climate change and its indicators in the Liban Jawi district?
- What are the main climate change adaptation methods currently being implemented by farmers in the Liban Jawi district?
- To what extent do different combinations of institutional, social, and environmental drivers affect the likelihood and intensity of adoption of climate change adaptation mechanisms?

➢ *Objectives of the Study*

- *General Objective*

The main purpose of this research was to determine the trends of climate fluctuation and determinants of farmers' adoption of climate change adaptation mechanisms in Liban Jawi Woreda, Oromia, Ethiopia.

- *Specific Objectives*

The following were the specific objectives for the study:

✓ To analyse the observed trends of key climate variables (precipitation and temperature) from 1990 to 2023 in the Liban Jawi district.
✓ To explore factors affecting farmers' adoption of climate change adaptation systems in the Liban Jawi district.
✓ To determine Liban Jawi district farmers' perception about climate change and variability (rainfall and temperature)
✓ To determine major climate change and variability adaptation trends in the Liban Jawi woreda.

➢ *Scope of the Study*

The research was aimed at studying the observed tendency of climate fluctuation over time and climate change adaptation techniques adopted by farmers in the Liban Jawi districts. This research was conducted at the district level and specifically examines trends in climate variability, including precipitation and temperature.

This study was also assessed farmers' adoption of climate change and adaptation strategies In Liban Jawi distict of oromia regional state for over the last 30 years. Finally, the questionnaire and focus group discussion also used to identify factors affecting farmers' adoption of local-level climate change adaptation techniques and identified main indicators for climate variability and change in the study area.

➢ *Significance of the Study*

The research provides information about the observed trends of climate variability and farmers' acceptance of climate variability and change, and their adaptation mechanisms from 1990 to 2023. It will be input for local policymakers and other development actors in planning and formulating policy that desires to initiate local farmer-dominant adoption experience and adaptation systems to bring down the climate change effect in Liban Jawi in their development intervention and build an economy that is fully or partially independent from the major effects of climate change, particularly in Liban Jawi and generally in Ethiopia and East Africa. The study will show the current trend of climate variability, the level of impact, and sources for different academic works that will be done on similar titles and references for the Office of Agriculture and Land Administration of the district.

➢ *Organisation of the Study*

This report is arranged into four major sections. The first section deals with the introductory part, providing the background information, addressing the problem, and emphasising the importance of the study, as well as research objectives. Chapter two is about the literature review. An overview of theoretical, conceptual, and empirical studies from a global to local point of view is a component of this division. The third chapter is about the methodology of the research. Chapter four is results and discussion, and the last chapter, five, is conclusion and recommendation. Lastly, the proposal with the appendix (questionnaire), tools for collecting data for the study, and meteorological data will be attached.

II. REVIEW OF LITERATURE

➢ *Concept of Climate Change*

As of IPCC (2001), climate is the average weather variability in amount for at least the last 30 years, and climate change is the variability of any of the main components of climate, like temperature, conditions, precipitation, and wind condition over a long time due mostly to anthropogenic and natural conditions (IPBES, 2019). There are many indicators for climate change, particularly of climate warming up, from the melting of ice and snow and the rise in average sea level globally. According to the IPCC (2007), in the 20th century, the world mean temperature and sea level increased by 0.74°C and 17 cm, respectively, where the main greenhouse gases contributing to this change are methane, carbon dioxide, CFC, and nitrous oxide, and almost all are due to human causes. The known sources of electricity for GHGs are energy supply sectors, like electric and industrial processes and fuel combustion; expansion of agriculture, particularly of livestock and rice production for methane emission; and deforestation spread all over the world. Vehicles, aviation, and shipping contribute the largest share to the transport sector. Relatively, the biggest share was carbon dioxide (51%), followed by chlorofluorocarbons (20%) and nitrous oxide (16%) up to 1990 (Singh, 2008).

The concentration of carbon dioxide in the pre-industrial era before 1750 was ~280 ppm, and in the 1960s it was ~315 ppm. In the 1990s, it increased to ~354 ppm, and in 2021 it reached 414 ppm and is projected to increase in the future. In recent past decades it has increased at a rate of about 2.3 ppm/year, mostly because of fossil fuels and deforestation for the expansion of agriculture, which leads to climate variability and change like heatwaves, droughts, and extreme rainfall; human health and livelihood impacts like food security and water availability; and loss of biodiversity (IPCC, 2021-AR6).

The impact of climate change on developing regions like Africa is extremely challenging due to low-level shock absorption and sensitivity to climate change and variability. Because of heavy dependence on rain-fed agriculture (70% of livelihoods; smallholders dominate), limited financial sources, weak infrastructure and institutions, and lack of access to technology, the effects were worse in Sub-Saharan Africa. With this serious bid problem, in the coming 21st century, in most parts of the continent, GDP will be predicted to be lost. For example, 2-7% in parts of sub-Saharan Africa, 2-4% in West and Central Africa, and 0.4-1.3% in North-South and Southern Africa (FAO, 2016). The World Bank and the African Development Bank estimate that climate change may reduce SSA GDP by 2–5% yearly, with some countries—particularly those dependent on climate-sensitive sectors—potentially suffering 5–10% of GDP by 2050 under moderate warming.

- *Climate Variability and Change in Ethiopia*

According to FAO (2011), the cumulative effect of climate change is negative; however, sometimes farmers in a few locations of the continent may benefit from the incremental effects of CO_2 emissions in terms of better production and productivity. In the long term its effect is more severe for poor local and marginalized farmers, particularly for the poor and marginalized, who in turn totally depend on natural resources and fragile agriculture for their livelihoods. Climate change is a key concern for Ethiopia and needs to be tackled in a state of emergency. It has led to an intensified load on already present environmental problems of the country, including forest degradation, continuous fertile soil degradation, and land degradation, which collectively lead to a decline in agricultural production and productivity (MOA, 2011).

- *Cause of Climate Change*

The cause for climate change is both natural and anthropogenic activities due to investing in fossil fuels and different industries that emit greenhouse gases into the Earth's atmosphere; currently, there is an increasing report showing the largest contribution is from human activities. The main cause is that fossil fuel burning from the energy and transport sectors emits carbon dioxide, while agricultural expansion and industrialization lead to methane and nitrous oxide compounds in the atmosphere. Although constituting less than 15% of total GHG emissions, methane is a very strong greenhouse gas, which is 23 times stronger than CO_2 (IPCC, 2007).

- *Causes of Rainfall and Temperature Variability in Ethiopia*

The cause for climate change can be due to human activity like burning fossil fuels, transport sectors, agriculture, and land use change, or natural external forcing such as volcanic activity and solar radiation (IPCC, 2014). The indicators for these changes are temperature and rainfall fluctuation and changes in the relative frequency, degree, and intensity of climate and weather extremes, explained as a persistent change in the average and changeability of climate variables such as temperature, precipitation, humidity, and soil moisture (Krishna, 2011).

Climate change has a long-term effect on precipitation and rainfall variability. The temporal and spatial expansion of drought and floods in Ethiopia is primarily due to increases in climate change variables like temperature. Because of the country's dependency on rainfed and subsistence agriculture, its vulnerability is complex and severe. Sea surface temperature changes and El Niño Southern Oscillation (ENSO) episodes in the Atlantic and Indian ~ Oceans do have remarkable implications for the timing and amount of rainfall in Ethiopia. Sea Surface Temperature and ENSO Influence on Ethiopian Rainfall tend to be positive when a warmer western Indian Ocean and cooler eastern side tend to enhance rainfall over East Africa, including Ethiopia, especially during the short rains (October–December) (IPCC, 2021).

The common variables considered to average climate change for at least the last 30 years are temperature, rainfall, and wind (IPCC, 2012).

Day-to-day variability of the atmosphere and short-period variations based on some specific local levels are called weather. It, in most cases, considers daily relative humidity, temperatures, wind speed, sunshine, and precipitation (Ramamasy et al., 2007).

The leading GHGs playing a role in climate change and variability are methane (CH_4), carbon dioxide (CO_2), chlorofluorocarbons (CFCs), nitrous oxide (N_2O), and ozone (O_3), but hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) are low in quantity but more powerful greenhouse gases in the atmosphere (Kiehl and Trenberth, 1997).

Adaptation is a process by which strategies to moderate, cope with, and take advantage 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. The term refers to changes in processes, practices, and structures to moderate potential damages or to benefit people and all stakeholder from opportunities associated with climate change (IPCC, 2007).

The ability of a system to cope with the negative effects of climate change, which can be due to natural or anthropogenic causes, its level of change, and the system's sensitivity determine the level of vulnerability of the system to climate change (Pittock, 2003).

Vulnerability is a cumulative effect of different factors, like the sensitivity and adaptive capacity of the system and the magnitude and rate of climate variation to which a system is exposed. Climate exposure of a system can be due to long-term climate change and short-term climate variability like daily atmospheric conditions, changes of temperature, precipitation, and exposure to extreme weather events like floods, droughts, and heatwaves (IPCC, 2001).

To manage during and immediately after climate-induced hazards using available knowledge and skills, resources, and available opportunities, it is important to consider options like early warning systems and protecting essential infrastructure during the hazard and damage and to conduct a need assessment, engage the community, restore critical services, and prevent disease outbreaks after climate-induced hazards (IPCC, 2021-AR6).

The projected temperature for Africa indicates that it will increase faster than all continents in the 21st century, and that is why Africa will become relatively warmer than other continents, with an increment of mean temperature of 3–4°C. (IPCC, 2014).

Climate variability and change in Ethiopia, particularly the highlands, experienced warmer temperatures over the last ten years, with high inter-annual and seasonal variability. Warming is noted during the dry season (December–February) compared to the rainy season, where there is an accelerated rate of heatwaves and extreme temperature events (IPCC, 2021).

- *Climate Change Impact*

Agriculture is ranked as the most susceptible sector to climate change impacts, and so are the livelihoods of subsistence farmers and pastoralists. Climate change particularly in developing country, exerts multiple stresses on the biological, physical, social and institutional enviro nments that affect agricultural production.

Because agriculture in developing countries, including Ethiopia, is rain-dependent, it is most affected by climate change, so that farmers and communities who entirely depend on agriculture are the most vulnerable to climate change. There are many symptoms of climate change already in sub-Saharan Africa, including Ethiopia, like drought, rainfall and heat waves, and they trigger secondary stresses mainly due to climate variability and change such as the spread of pests, increased competition for resources and biodiversity losses (Christensen et al., 2007).

However, it is difficult to predict the socio-economic consequences and the impact of climate change on socio-economics and the environment. Indicators are showing a decline in production and productivity and a challenge to provide food security, but the impact may differ based on region and the type of agricultural activity in a particular region. For instance, mixed cropping is more adaptive when compared to monocropping. Many reports showed that Africa's agriculture is more susceptible to climate change because of low levels of economic development and adaptive capacity. (IPCC, 2007; Lobell et al., 2011).

- *Climate Change and Agricultural Sectors of Ethiopia*

The Ethiopian agricultural sector depends mostly on rainfed agriculture, and the country has different agroecological zones with different microclimatic zones, so that farmers practise different farming activities in different seasons because agriculture is the source of livelihood (CSA, 2007).

A report of the MoA (2000) indicated that Ethiopia's agro-ecological zones can be grouped into six major categories which consider arid zones (31.5%), semi-arid (3.5%), sub-moist (19.7%), moist (25%), sub-humid and humid (19.3%) and per-humid, which covers close to 1% of the country.

Climate is the primary causal factor of Ethiopian economic growth because of the agriculture sector, which is the backbone for economic development of the country. The main agricultural practices are cereal (teff, maize, and wheat) and oil crop production, livestock husbandry, forest (timber, fuelwood, and environmental conservation), and fishery development. Crop production responsible and (70.2%), livestock (20.3%), and forestry and other subsectors (9.5%), Agriculture play the biggest role in food self-sufficiency and accounting for 39% of the contribution of agriculture to the country's GDP at the end of 2014/15 (FDRE, 2016).

Rainfall failure, floods, drought, and other changes in the country's natural and environmental system due to climate change threaten the performance of the economy as a whole and cause severe malnutrition and loss of livelihoods for households, mainly in marginal and less productive lands in the country (PANE, 2009). This effect is attributed to the fact that those changes can seriously depress agricultural production in the country.

This demonstrates that economic growth in general and households' welfare in particular are significantly influenced by changes in rainfall, temperature and other climate variables (World Bank, 2006). This shows that the impact of climate change in the country can be felt not only on agricultural output but also on other sectors of the economy. Many studies have concluded that the agriculture sector of the country is the most affected sector by climate change. The trends in the contribution of agriculture to the country's total GDP clearly explain the relationship between the performance of agriculture, climate, and the total economy.

➢ *Climate Change Perception*

In areas/regions where livelihoods depend on agriculture and people are agrarian, the the interconnection between climate and agriculture is more complex, and farmers follow a suitable season for crop production based on local knowledge of forecasting weather from farmers' long-term experience and knowledge. They also have a culture of predicting long-term change like climate (Burton et al., 1992).

Farmers everywhere have already internalised that there is a change in climate at their local place and perceive it as increasing temperature, reduced or erratic rainfall, frequent droughts and floods, and changes in the growing season due to seasonal variation of rain and temperature. Farmers apply different adaptation techniques based on their perception and cultural and traditional knowledge systems (FAO, 2016).

In Africa, particularly in Sub-Saharan Africa,70 percent of farmers believe there is a change in climate use indicators like increasing temperatures and unpredictable precipitation, changing in growing season and crop failure or reduction in production and productivity are common indicators and, it is worst in Africa because of constrained by access to resources, extension services, and markets (FAO (2018).

➢ *Climate Change Adaptation Strategies*

Although Climate is changing almost everywhere globally, its effects from region to region were not the same (UNFCC, 2007). It involves long-term change and fundamental fluctuation in variables like precipitation, hotness/coldness, wind condition, and direction (IPCC,2007)

Livelihood of 80% of the population of Ethiopia depends on rain-fed agriculture, and Agriculture also has a share of 49% of countries GDP, more than 80% of the foreign exchange (Yehualashet & Rajan, 2014). Recurrent drought becomes hyper critical climate issue, which leads to a loss in production and affects the national economy (Wako, Tadesse, & Angassa, 2017). Both adaptation and mitigation are common policy responses for global warming. Since Mitigation alone cannot solve the increasingly changing global warming, adaptation options are also considered to prevent short-term climate change, whereas mitigation reduces further warming or reduces the expected negative impact (Parry et al., 2007).

The concept of Adaptation is to support Agricultural practices to adjust to actual or expected climate impacts due to global warming with the objective of increasing the resilience of the agricultural system (protecting livestock, crop, forest), supporting sustainable livelihoods, and able to secure food production systems from climate-related negative impacts (UNFCCC,2011).

Mitigation, on the other hand, is a measure taken to reduce (GHG) emissions or boost carbon sequestration from different sectors, including agricultural systems like fertilizers, livestock(methane), and land use conversion. It promotes conservation tillage, agroforestry, low-emission development pathway (UNFCCC, 2019).

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 problems caused by climate change they face. This is because the impact of climate change is unevenly distributed over different geographic areas and hence the adaptation mechanisms also vary with the the types and levels 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 literature. These include changing planting dates, changing crop variety, mixing crop and livestock production, planting short-season crops, planting trees, decreasing livestock, moving animals or temporary migration, changing livestock feeds, soil and water management, changing from livestock to crop production, changing animal breeds, irrigation or water harvesting, and seeking off-farm employment. These are among some of the several strategies available to enhance social resilience in the face of climate change (Hassan, 2007).

Studies carried out independently by Temesgen et al. (2009), the World Bank (2010), and Mengistu (2011) 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-arden agriculture are among the common adaptation strategies farmers carry out in response to climate change. Even though there is a wide range of adaptation options, there is no assurance that a particular farmer will undertake an 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, informational, skill-based, infrastructural, and institutional characteristics (Munasinghe and Swart, 2005).

- *Empirical Literature on Determinants of Adaptation Strategies to Climate Change*

Different studies regarding farmers' perception and determinants of mitigation adaptation strategies to climate change. I carried out in different countries, including Ethiopia. In the following section, a review of the most important empirical studies are presented.

Hassan (2007) examined farmers' adaptation strategies to climate change in countrty of southafrica, Zambia, and Zimbabwe. The aim of the study will to wasdescribe farmers' perceptions about long-term changes in temperature and precipitation, as well as various farm-level adaptation measures and barriers to adaptation. The results indicated that using different crop varieties, crop diversification, changing planting dates, practicing new livelihood and switching from farm to non-farm activities, increased use of irrigation, and increased water and soil conservation techniques were the different adaptation measures employed by farmers in these countries. The study also reported that most farmers perceived a long-term increase in temperature and that the region will be get drier, with changes in the timing of rains and frequency of droughts. Bryan et al. (2009) analysed adaptation strategies used by farmers in South Africa and Ethiopia. The study contained 800 observations from 19 districts of 4 provinces of South Africa and 1000 observations from 20 kebeles in 5 regions in Ethiopia. The researcher was analysing data by using both descriptive and probit mode) methods of analysis. The result shows that, in both countries, as collected and analysed data indicated, a large share of farmers' perceived temperature had been increasing over time, and that rainfall had been decreasing. And the study found out the commonly crop used adaptation strategies such as use of different crops varieties, planting multipurpose trees, mobilizing community for soil conservation, changing planting dates, and irrigation. Lack of access to credit in South Africa and lack of access to land, information, and credit in Ethiopia were identified as the main barriers to adaptation. The analysis of factors affecting adaptation indicated that farmers with access to extension, credit, and land. Food aid, extension services, and information on climate change were more likely to be adopted and found to facilitate adaptation.

Temesgen et al. (2008) analysed determinants of farmers' choice of adaptation methods in the Nile Basin. Cross-sectional data collection was used from a survey of farmers, the study found that the adaptation methods currently practiced in the study area. Such as changing planting dates, using different crop varieties, planting tree crops, irrigation, and soil conservation, and not adapting. The farmers reported that the reasons for not adapting are lack of information on climate change impacts and adaptation technologies, lack of financial resources, labour constraints, and land shortages. Level of education, Ageas older have long experience, sex, and household size of farmers were found to be significant determinants of adaptation to climate change in the study area.

Aemro et al. (2012) studied climate change adaptation strategies of smallholder farmers: the case of Babilie district, East Hararghe zone of Oromia National RegionalState. The study covered 160 households. The collected data were analysed as qualitatively and quantitatively. Multinomial logistic regression analysis used to analyse the factors influencing households' choice of adaptation strategies to climate change. The result from the multinomial logit analysis showed that sex of household heads, age of the household head and education level of the household head, family size, livestock ownership, household farm income, non-farm income/off farm, access to credit, distance to the market centre, access to farmer-to-farmer extension, agro-ecological zones, and access to adaptation strategies. Farmers' perception and determinants of mitigation adaptation strategies to climate change are determined by many factors. These factors include the household socio-economic status (assets, on-andoff-farm income), demographic characteristics (sex, farming experience, literacy status), institutional factors (extension service, market distance, credit), and mitigation mechanisms. These are the most important variables identified by much literature in determining whether or not farmers perceive mitigation and adaptation strategies used to cope with climate change's adverse effects.

Different empirical studies have been carried out regarding perception and determinants of adaptation strategies to climate change. Ehui et al. (2004) pointed out that some known determinants tend to have general applicability, is difficult to develop a universal model of the process of adaptation strategies with defined determinants and hypotheses that hold everywhere. This is difficult because of the socio-economic and ecological distinctiveness of the different sites and the dynamic nature of the determinants, since there is a repeated need for analyses under different conditions. It is very important to clearly understand what is happening at the community level, because farmers are the most climate-vulnerable group. Hence, the following framework depicts the most important way expected to determine the farmers' perception and adaptation strategies to climate change, taking into account the specificity of Liban Jawi District.

- *Conceptual Framework*

The following analytical framework depicted the most important variables expected to influence the farmers' choice of adaptation practices to climate variability and change in the case of Liban Jawi District.

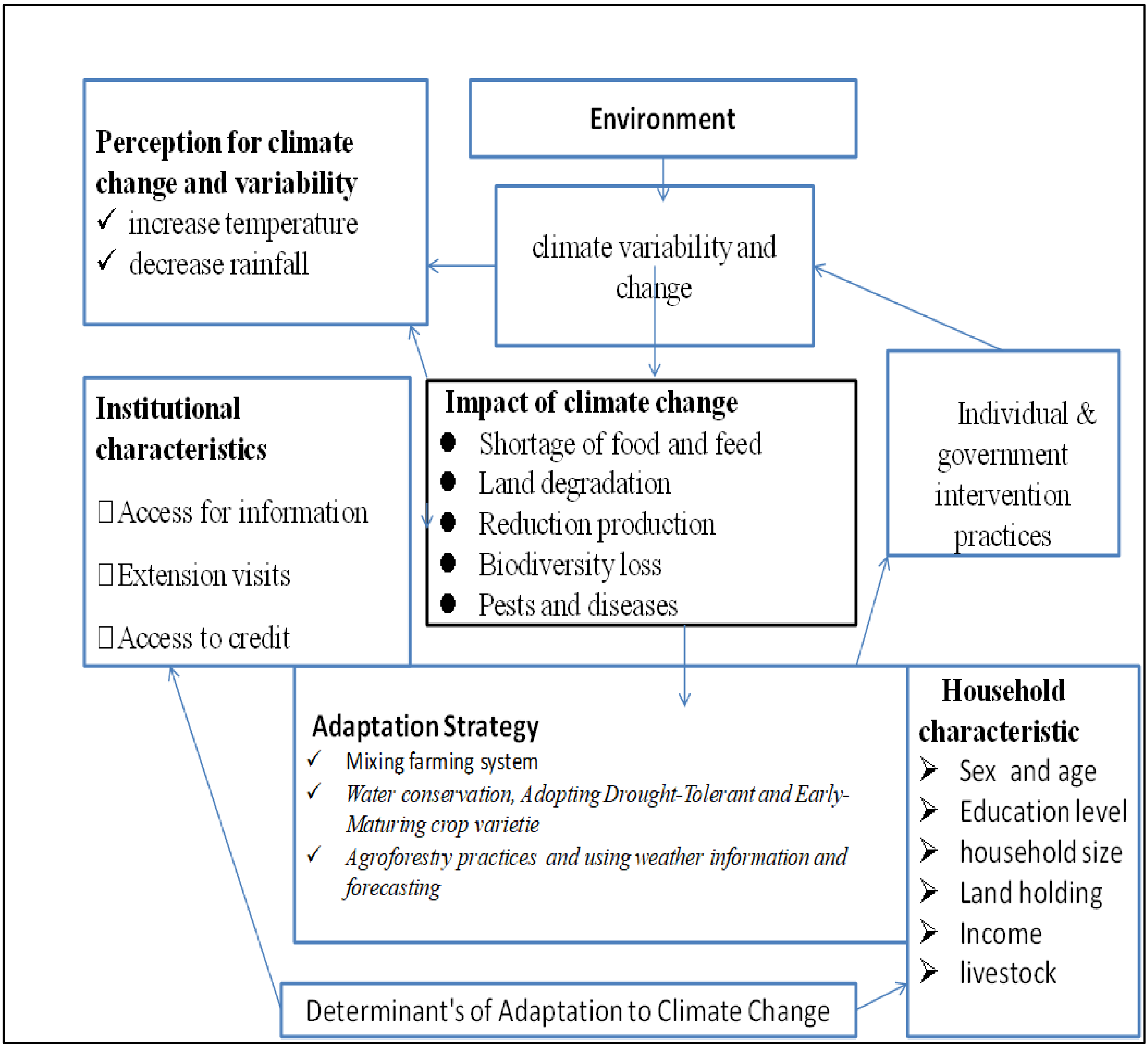

Fig 1Conceptual Framework
Source: Developed by Researcher, 2025

III. METHODOLOGY

➢ *Description of the Study Area*

Geographical Location of Liben Jawi Woreda is in West Shoa zone of Oromia Regional State, Ethiopia.The woreda is found on distance of 159 km from Capital city of The Country which is Finfine and 50 km from the zone administration, Ambo town. Liban Jawi has boundary with different districts in the zone including Mida Kegni district on the North, Jibat district on the South, the district of Toke Kutaye on the East, and Cheliya district on the West. Geographically, the district is located 8°50'58"-8°54'4"Latitude/North, and 37°22'21"-37°37'56" Longitude/East; and total area of land in districts is 328.37km2. The district consists of 15 rural kebeles and 1 urban kebele which is called Babich with total households of 9,578 (9,128 rural and 450 urban) and its population size is estimated to be 70,820 (35,376 male and 35,444 female), and population density of 216 per square kilometer. The average yearly temperature can varied from10° to 25°C; and the average annual precipitation oscillate be from 900-1800mm. The district has a diverse topography with an altitude that varies between 1100 and 2900 meters above sea level (m.a.s.l). The main agro climatic zones of the district are low land 19%, mid-highland (75%) and highland (6%). Households in the district own fragmented agricultural land; and mixed farming and livestock production are the the main livelihood activity for the community. The farming season is dependent on the summer (‘Kiremt’) rains that start in May and last until October and the main hunger season is from May to August (Liban Jawi Agriculture and land office,2024).

➢ *Map of Location of the Study Area*

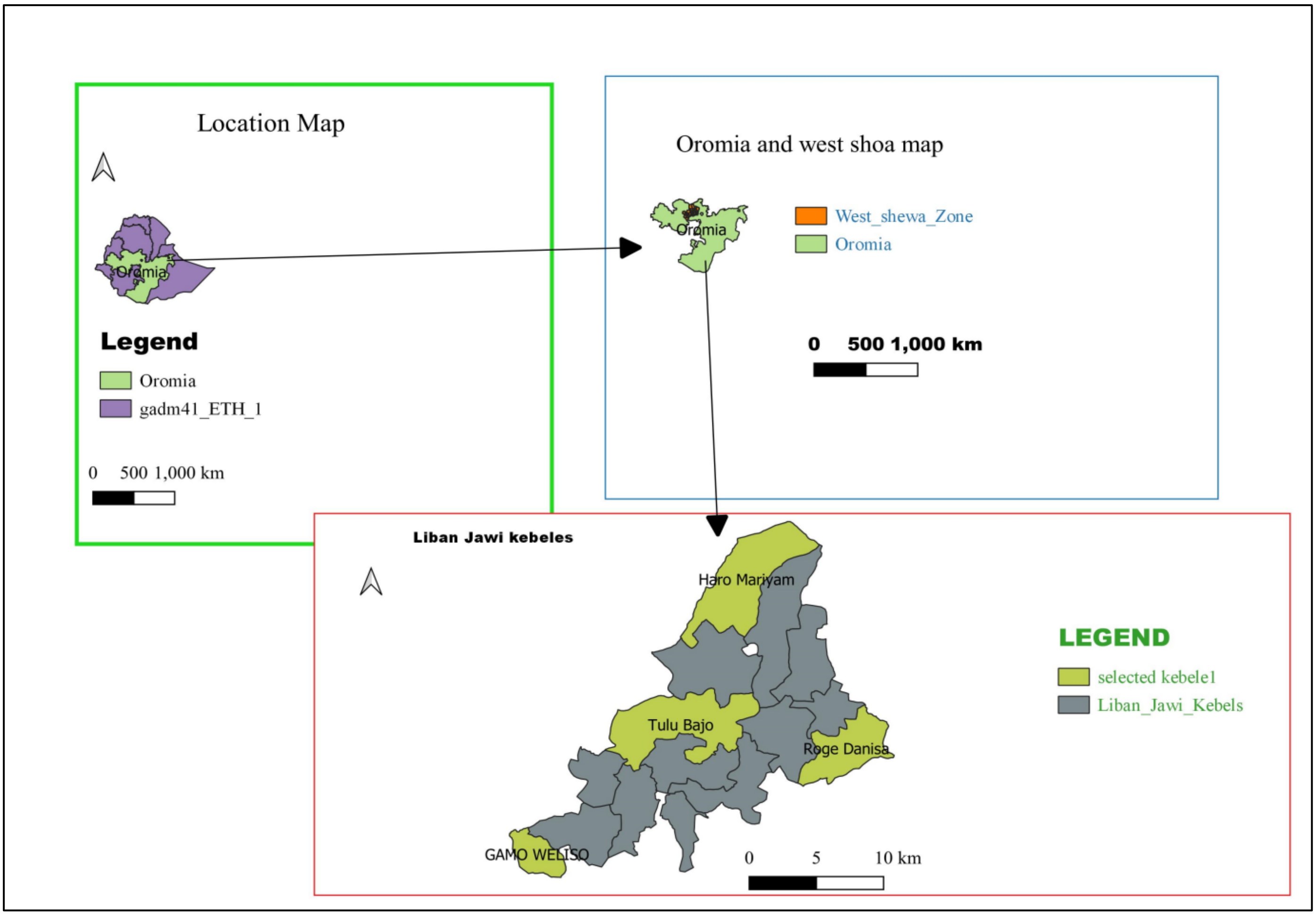

Fig 2 Location Map
Source: Mapped by the Researcher

➢ *Research Design*

This study was conducted by descriptive cross-sectional and longitudinal data surveys. A descriptive cross-sectional survey is essential for providing a snapshot of the current practice. A descriptive survey design is a process of gathering information through interviews and/or administering a questionnaire to a representative sample of selected individuals (Orodho et al., 2013).

This design also helps the researcher to get as current, available, and detailed information as possible on the issue under consideration. It also permits the researcher to collect data via different tools such as interviews and questionnaires. It was employed in the study because the design is appropriate to collect details of data from many respondents, and it is widely used in the social sciences. Furthermore, it helps to describe what reality is or what exists within a situation, such as current practices, progress, and situations of different aspects of the research.

The longitudinal design is commonly used in meteorological research to study changes in weather patterns and climate conditions over an extended period. This design involves collecting data at multiple time points over a considerable duration, allowing researchers to examine trends, fluctuations, and long-term patterns in meteorological variables (Diggle et al., 2002).

➢ *Research Approach*

Both qualitative and quantitative study approaches were employed. According to Bryman (2016), using such approaches gives depth and breadth to the findings and allows looking at the issue from a different perspective. Moreover, quantitative data-gathering techniques have been used to condense data to see the bigger picture; the qualitative approach permits one to see things in their broadest sense and to know more about something than he or she did before engaging in the process (Saunders et al., 2009).

➢ *Type of Data*

To examine trends of climate variability and change, primary and secondary data sources were collected and analyzed. A combination of primary and secondary data sources helped to triangulate the outcomes and ensure reliability.

➢ *Primary Data Sources*

To realize the target, the study used a well-organized questionnaire as the best instrument. The questionnaire was completed by selected farmers and other district and kebele concerned officials concerning the current trend of climate variability and change, and farmers' adoption of climate change adaptation strategies. Primary data used in the research were collected through observation, group discussions, key informant groups, and interviews with key informants in the Liban Jawi district from a sample frame on a random basis.

- *Secondary Sources*

Secondary data from files, pamphlets, office manuals, circulars, and policy papers were used to provide additional climate information. Besides, a variety of books, published and/or unpublished government documents, websites, reports, and newsletters were reviewed to make the study fruitful for the purpose of formulating appropriate variables, making the questionnaires, and interpreting the statistical results of the hypothesis.

- *Target Population*

Population is the whole group of individuals, phenomena, or things that the research aims to generalise results on. In this study, the target population consisted of all households that participated in maize crop farming from selected Kabeles in the Liban Jawi district. The reason for selecting households is due to their participation in cultivating at least one crop either on their land or by contract on fixed land or traditional agreement. From 16 kebeles, one is an urban kebele, and all rural householders from four kebeles were selected, and a sample frame of 1450 households was listed for the drawing sample.

- *Sample Size and Techniques*

The total population (households of the four kebeles) was 1450, and the survey included 159 male and 153 female household heads using a simple random sampling technique, which is greater than 21.5% of the total households. Yamane's (1967) sample size determination formula was used because time and resources are limited, we need a quick estimate of the sample size, and there is no need for stratification or advanced techniques. It provides a simplified formula to calculate sample sizes. The variability in the population was maximum (i.e., p = 0.5), and the confidence level is 95%, with Z = 1.96, and we use the following formula to determine sample size.

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

Where: n = required sample size

N = total population size

e = margin of error (level of precision, usually 0.05 for 95% confidence)

$$no= \frac{1450}{1+11450(0.05)^{(2)}} \frac{1450}{1+1450(0.0025)} = n= 312$$

$$ni= \frac{n}{N} *312$$

Were

ni- is the required sample size for the kebele**,**

n- Is the total number of households in specific kebele

N-is the total number of households in in the study area.

Table1 Sample Size by Kebele

Name of Kebeles	Total number ofhouseholds	Kebele Sample size (ni)
Mid Highland	1088	234
Tulluu Baajoo	651	140
Haroo Maramii	437	94
Low land	276	59
Gaamoo Waliso	276	59
Highland /Dega	87	19
Roge Danisa	87	19
Total		312

Source: Household Survey (2024)

- *Definitions of Variables and Research Hypothesis*

- *Dependent Variable,*

The study focuses on four dependent factors for farmers' choice of different climate change adaptation practices. The researcher had identified four dependent factors as mixed cropping, soil and water conservation, adopting drought-tolerant and early-maturing varieties, agroforestry practices and climate information and forecasting based on preliminary studies and different literature reviews**.**

- *Independent Variables*

Independent variables that affect farmers' decisions to adopt climate change adaptation strategies in the study area, particularly the characteristics of the household, farm characteristics, and institutional factors, are hypothesized to explain the dependent variable. Much literature and preliminary studies indicated the following as potential factors affecting farmers' decisions to adapt to climate change.

- *Gender:*

"1" for a woman and "2" if the household head is a man. Gender positively influences the use of climate change adaptation practices due to the unbalanced dissemination of information between men and women many times.

- *Age of the respondents**:***

Age can positively or negatively affect farmers' adoption of climate change adaptation strategies. Several studies suggest that as a farmer's age increases, their likelihood of adopting adaptation strategies decreases. Some studies suggest that the older the farmer, the more experienced he/she is in farming, and the more he or she is exposed to past and present climatic conditions, which can increase adoption of climate change management adaptation technologies. The expected sign in this current study is either positive or negative. refers to age: 1 (18-29), 2 (30-44), 3 (45-60), and 4 (>=60).

- Level of Education

Education can improve farmers' learning of new farming technology and access to information from different sources, like media and publications, so that it increases the level of adoption of new technologies and adoption of climate change adaptation strategies in the study area. Level of education indicated as 1=None, 2=Primary, 3=Secondary, 4=University

Household size (hhsize) refers to the individuals currently living together as a family and directly or indirectly affected by climate change.

- *Total Land Size (Farm Size):*

Can be cropland, forest land, grazing land, or park and reserved land, and was measured in hectares. Land is a very important resource, especially for an agrarian country, and it is an indicator of the wealth of the community. Farmers with large land sizes preferred to use different climate change adaptation practices.

- *Off/Non-Farm Income:*

It is a dummy variable, which takes a value of 1 if the farm households have off/non-farm income or 2 otherwise. It represents the activities other than the farm activities, such as crops and livestock. The availability of off/non-farm income affects the probability of adaptation positively since it can increase the farmer's financial capacity to participate in climate change adaptation practices. Therefore, it is expected to positively affect the farmers' use of adaptation practices.

Farming experience (farmexp) is to be measured in the number of years since a respondent started farming activities. The higher the experience of the farmers, the better the information and knowledge. Hence, the farming experience of the respondents will be hypothesized to affect the use of climate change adaptation practices positively.

- *Access to Credit:*

Limited access to credit is one of the factors hindering farmers' participation in climate change adaptation practices. Credit facilitates the introduction of new farm machinery and access to improved seeds and fertilizers. In this study, the variable is coded as 1 for farmers with access to credit and 0 otherwise.

- *Access to Climate Information:*

Access to climate information enables farmers to understand risks such as drought and crop and livestock failure, thereby supporting informed decisions on adaptation strategies. This variable is a dummy, coded as 1 for farmers with access to information and 2 for those without. It is expected to have a positive influence on farmers' attitudes toward adopting climate change adaptation measures.

- *Extension Agents' Influence*

Extension workers can support farmers by providing updated information regarding climate-available seed and climate-smart agriculture and technology through formal training and farmers' field schools. So, as farmers interact with development agents, it positively impacts their participation in adaptation practices. A value of '0' if never visited the development agent, '1' if visited sometimes, '2' if visited mostly, and '3' if visited often/always by the extension agent. Extension contact has the package, such as advice, training, information, demonstration, and distribution of agricultural inputs. The frequency of extension contacts increases farmers' use of adaptation methods to climate change.

- *Agroecological Zone (Agroeco):*

Agroecology is one of the main factors that determines opting practices for climate change. Variables are coded as taking 0, 1, and 2 if farmers are living in lowland, midland, and highland, respectively. Using different climate change adaptation strategies can be influenced by the agroecology's where farmers reside.

- *Membership in Local Institutions:*

Membership in local institutions provides farmers with opportunities to exchange information on improved seeds, agricultural inputs, available technologies, credit options, and effective climate change adaptation strategies. However, these institutions vary from place to place; most take the form of cooperatives, religious associations, Ikub (traditional savings groups), Dugda (reciprocal work groups), and self-help groups such as Idir/Afosha and Debo/Jigi. They can play a positive role in promoting the adoption of adaptation measures in response to climate change and variability.

➢ *Tools for Data Collection*

The following tools were used to collect important data from selected sources.

- *Questionnaire*

Both open- and closed-ended questions were ready to identify the perception of farmers on climate variability, change, and adaptation practices and distributed to 312 household heads, development agents, Liban Jawi, agriculture and land administration experts, and officials.

- *Key Informant Interview (KII)*

The KII was conducted with development agents from selected kebeles (6) and Woreda Agriculture and Land Administration Department experts (6) and community representatives.

- *Focused Group Discussion (FGD)*

Six respondents were selected for FGD and guided by a trained moderator to collect information on research questions and objectives from each kebele.

The selected individuals were known to have the best knowledge and skill on present and past climate variability and change from women representatives (1), local kebele elder representatives (2), religious representatives (2), and youth and development agents (1) from each selected/sample kebele. The objective of FGD is to determine the trends of climate fluctuation and determinants of farmers' adoption of climate change adaptation mechanisms, indicators of climate change, and common adaptation practices in Liban Jawi Woreda.

- *Method of Data Analysis*

Data collected through various qualitative and quantitative approaches and tools were first cross-checked for accuracy before analysis. Historical trends in key climate variables—such as temperature, precipitation, rainfall patterns, and the relative frequency of extreme weather events—in the study area over the last 32 years (1991–2023) based on data from the Ethiopian National Meteorology Agency were used. The coefficient of variation (CV) was calculated by dividing the standard deviation of rainfall and temperature by their respective means. A higher CV value indicates greater variability, while a lower CV value reflects less variability in both temperature and rainfall. R software (version 4.4.3) was employed to generate box plots and line plots illustrating trends in temperature and rainfall. Multiple linear regression analysis was conducted to examine the relationship between independent variables (education, training, and membership in farmers' organization's) and the dependent variable (adoption of climate change adaptation practices).

Farmers association, membership in savings and loans associations, off-farm employment, marital status, gender, and age as independent variables), Man-Kendall (MK Z) and Sen's slope estimator were calculated using R software, SPSS version 26 for logistic regression analysis on farmers' adoption of climate change adaptation strategies. The MK test is used for identifying trends for most environmental and climate variables, just to show whether a trend is increasing or decreasing over a specific time. The Z score was calculated and analysed as $Z > 0$: increasing. $Z < 0$: decreasing and $Z \approx 0$: no trend (Yue, S., 2004). Coefficient of variation = standard deviation (σ) / mean precipitation/temperature (μ) X 100. CV values less than 20 indicate low variability; CV between 20 and 30 indicates moderate variability, whereas CV greater than 30 shows high variability.

IV. RESULT AND DISCUSSION

- Characteristics of Respondents

This research result was from both qualitative and quantitative data collected from 312 sample households interviewed during the survey. Among 312 household heads (HH) who participated in the survey, 51% and 49% were male and female, respectively. The marital status of respondents was 63.1% married, 9.3% widowed, 18.6% divorced, and 9% single from the sampled households, while the agroecological setting of the respondents was lowland (19%), midland (75%), and highland (6%). As can be seen below, the age and educational status of the HH majority Ages were 45-59 (>60, 30-44, and 18-29), at 47.6%, 25.5%, 20.4%, and 5.8%, respectively, and the educational status of the majority of respondents was primary, secondary, university, and not attending any formal education (44.4%, 31.6%, 19.5%, and 4.2%, respectively).

Table 2 Respondents Characteristics (N=312) (Categorical Variables)

House hold characteristics		Freq.	Percent
Sex	Female	159	51
	Male	153	49
	Total	312	100
Agro ecological setting of respondents	Lowland	59	19
	Midland	234	75
	Highland	19	6
	Total	312	100
Marital status	Married	290	63.1
	Divorced	9	18.6
	Widowed	6	9.3
	single	7	9
	Total	312	100.00
Age	45-59	149	44.4
	>60	81	31.6
	30-44	64	19.5
	18-29	18	5.8
Education	illitrate	61	19.6
	primary	139	44.6
	secondary	99	31.7
	university	13	4.2

Source: Author Compilation, 2025

➢ *Local Community Response to Climate Variability and Change*

Farmers in the Liban Jawi district were interviewed to identify how they perceived climate variability and change in their area for the last 30 years. Subsequent questions were asked to know their perception of whether it increased or decreased, particularly on rainfall and temperature. The local community, development agents, and district-level stakeholder perception of climate variability and change, particularly of temperature and precipitation characteristics of the study area in the past, was examined. The results show that a higher percentage of respondents confirmed that temperature and rainfall status had increased and noted extreme weather changes in the frequency of floods. Processed information indicated that almost all of the respondents perceived that there was a change in precipitation and temperature in Liban Jawi over the last 30 years. Local communities have been experiencing an increase in precipitation and little change in the temporal and spatial distribution of precipitation over the past 30 years. Almost 174 households (55.8%) agreed that there has been an increase in precipitation, while 254 households (81.4%) agreed that there has been an increase in temperature. In the study area, 128 perceived decreased precipitation, and 49 said temperature decreased over the last 33 years. A large number of farmers participated in the survey, and interviews and focus group discussions revealed that they are knowledgeable about climate variability and change, with an increasing temperature and rainfall in the Liban Jawi district.

The figure below shows the direction of the perceived changes in rainfall and temperature level by the farmers in the study area. As of Figure 3 clearly indicates, approximately 174 and 254 respondents perceived an increase in rainfall and temperature levels, respectively, while approximately 128 and 49 respondents perceived a decrease in rainfall and temperature levels, respectively. Similar to my result, Birhanu et al. (2017) analysed climate data from Southern Tigray and found significant increases in both temperature and precipitation over 30 years. Research conducted in the Upper Blue Nile Basin identified notable increases in both maximum and minimum temperatures, along with changes in rainfall extremes over a 33-year span. These findings highlight the region's vulnerability to climate variability and the necessity for adaptive strategies (Mersha, Taye, & Dile, 2022).

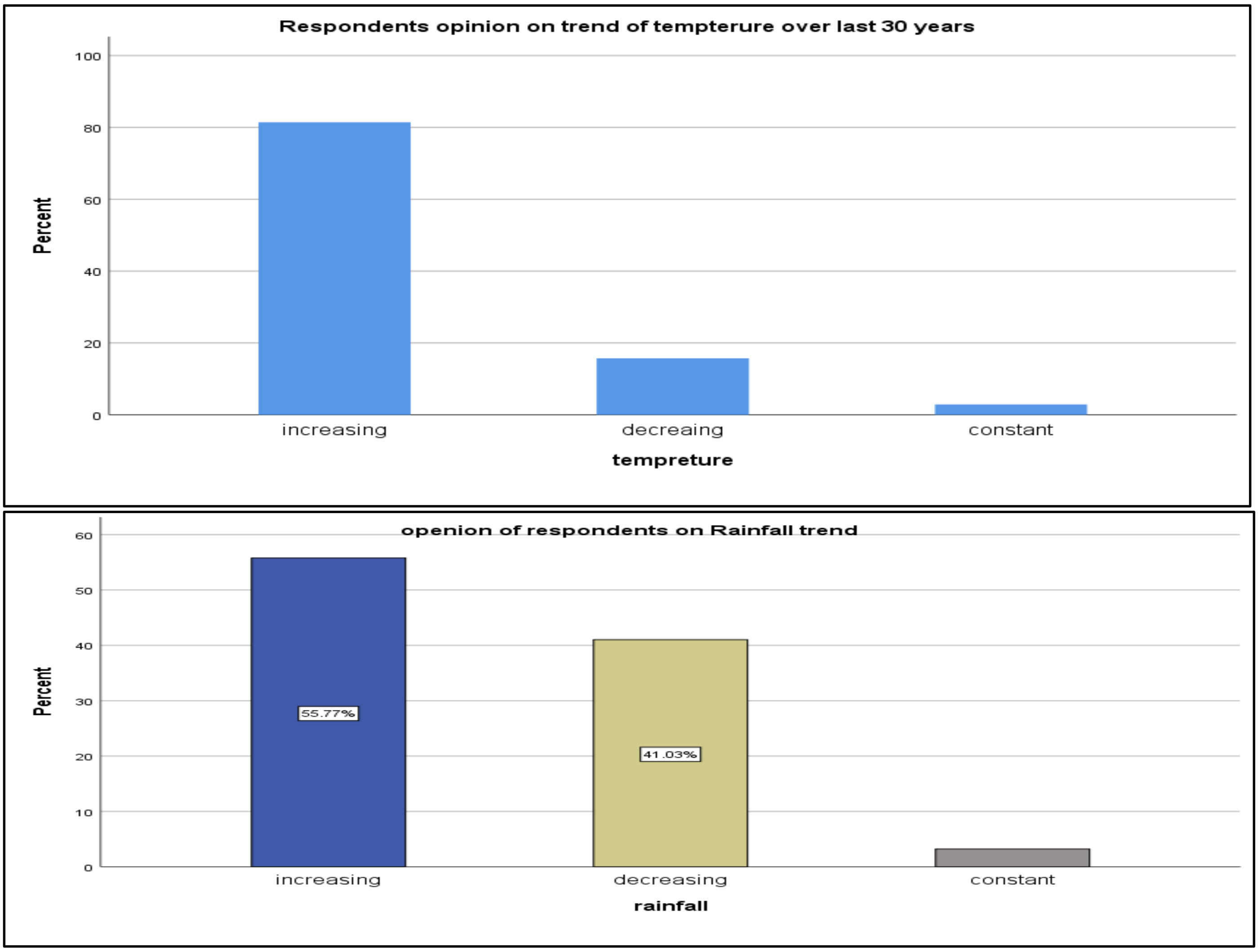

Fig 3 Farmers' Response About Change of Rainfall and Tempreture in Liban Jawi District
Source: Computed by Researcher Based on Respondents Perception

➢ *Indicators of Climate Variability and Change*

In this study, local communities were asked about indicators for climate variability and change over the last 30 years. Their responses revealed that there is a change in rainfall and temperature (116/312), a decline in productivity (101/312), erratic rainfall (52/312), and extreme weather events (43/312). The respondents and observations during the survey show that the primary climate concepts that had changed in this area were precipitation and temperature. My result indicated complementarity with Mertz, O., Mbow, C., Reenberg, A., & Diouf, A. (2009). Farmers in rural Sahel reported declining crop yields over recent decades, which they attributed to increased climate variability, including delayed onset and early cessation of rainfall.

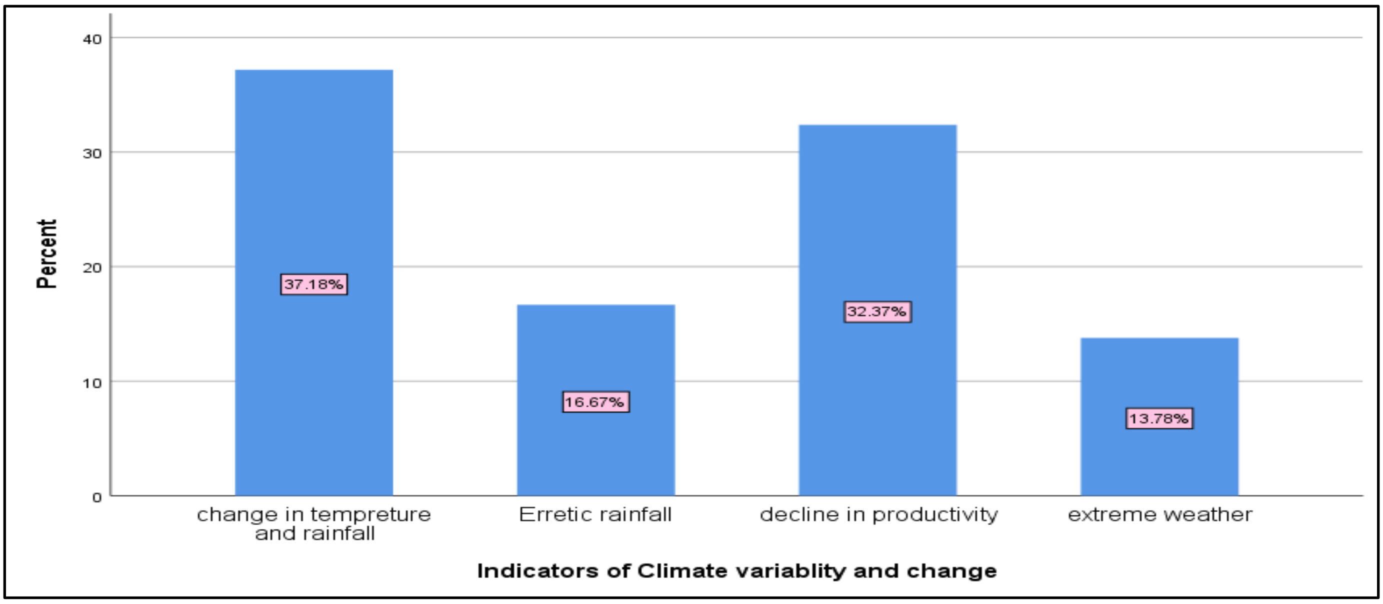

Fig 4 Indicators of Climate Variability and Change in Liban Jawi Districts
Source: -Generated by Researcher based on Respondents Perception Indicators of Climate Variability and Change.

➢ *Trend and Variability Analysis of Rainfall*

- *Trend Analysis of Rainfall*

To know statistical parameters (mean, standard deviation and coefficient of variation) of annual and seasonal precipitation series for the period of 1991-2023 the preliminary data analysis was carried out. Annual precipitation in Liban Jawi district varied between 904 mm (2004) to 2515 mm (2018) with a standard deviation of 465 mm. Coefficient of variation (CV) is the measurement of dispersed data points in data series around the mean which is found 26.5%.

Table 3 Satistical Parameters for Rainfall

Time Series	Mean	Minimum	Maximum	SD	CV
Spring (MAM)	392.02	99	669	129.74	33
Summer (JJA)	852.19	440	1339.5	234.3	27.4
Autumn (SON)	462.6	65	869	181.87	39
Winter (DJF)	51.6	5.7	239	46.8	90.8
Annual RF	1758.4	51.6	852.12	465	26.4

Note: SD=Standard Deviation and CV=Coefficient of Variation
Source: Computed based on Statistical Raw Data of NMSA 2024, for the Period (1991-2023)

The mean annual rainfall of the study area was 1758.4 from 1991 to 2023. The summer season is the main rainy season with frequent and heavy rainfall, often with homogeneous temperatures, and spring is the short rainy season. The long-term mean annual and seasonal rainfall was unevenly distributed in the districts. The highest mean annual rainfall variability (CV) is 26.5% in the Liban Jawi district, which is moderate in terms of variability for rainfall (20% < CV < 30%). Rainfall shows a noticeable degree of fluctuation. This level of variability can pose some challenges for planning.

Since our CVs in spring and autumn are 33 and 39, respectively, they are categorised as high variability (CV > 30%). Rainfall is quite erratic and unpredictable, which can significantly impact water availability and agriculture and increase the risk of droughts and floods.

The calculated coefficient of variation (CV) for winter rainfall is 90.8%, which is exceptionally high (above 70%). This level of variability indicates highly erratic rainfall patterns, substantial uncertainty, elevated risk of extreme events, and significant implications for water resources, posing considerable challenges for adaptation in the area.

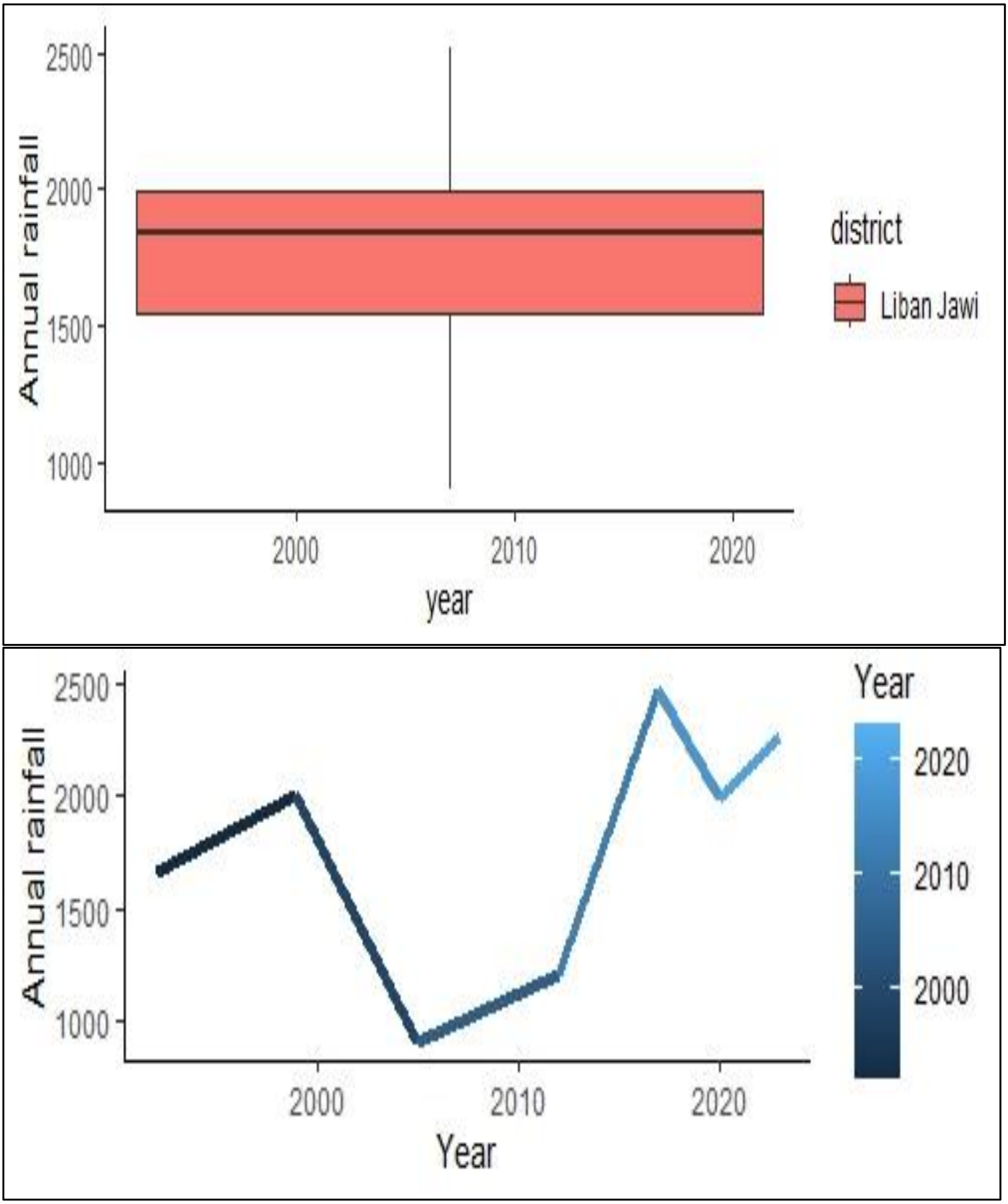

Fig. 5 Box Plot for Annual Rainfall (1991-2023) Compiled by Researchers
Source: Generated by Researcher Based on Meteorological Data

The box plot (Figure 5) indicates that the mean value is about 1750. The minimum rainfall is below 1000 mm and goes above 2500 mm.

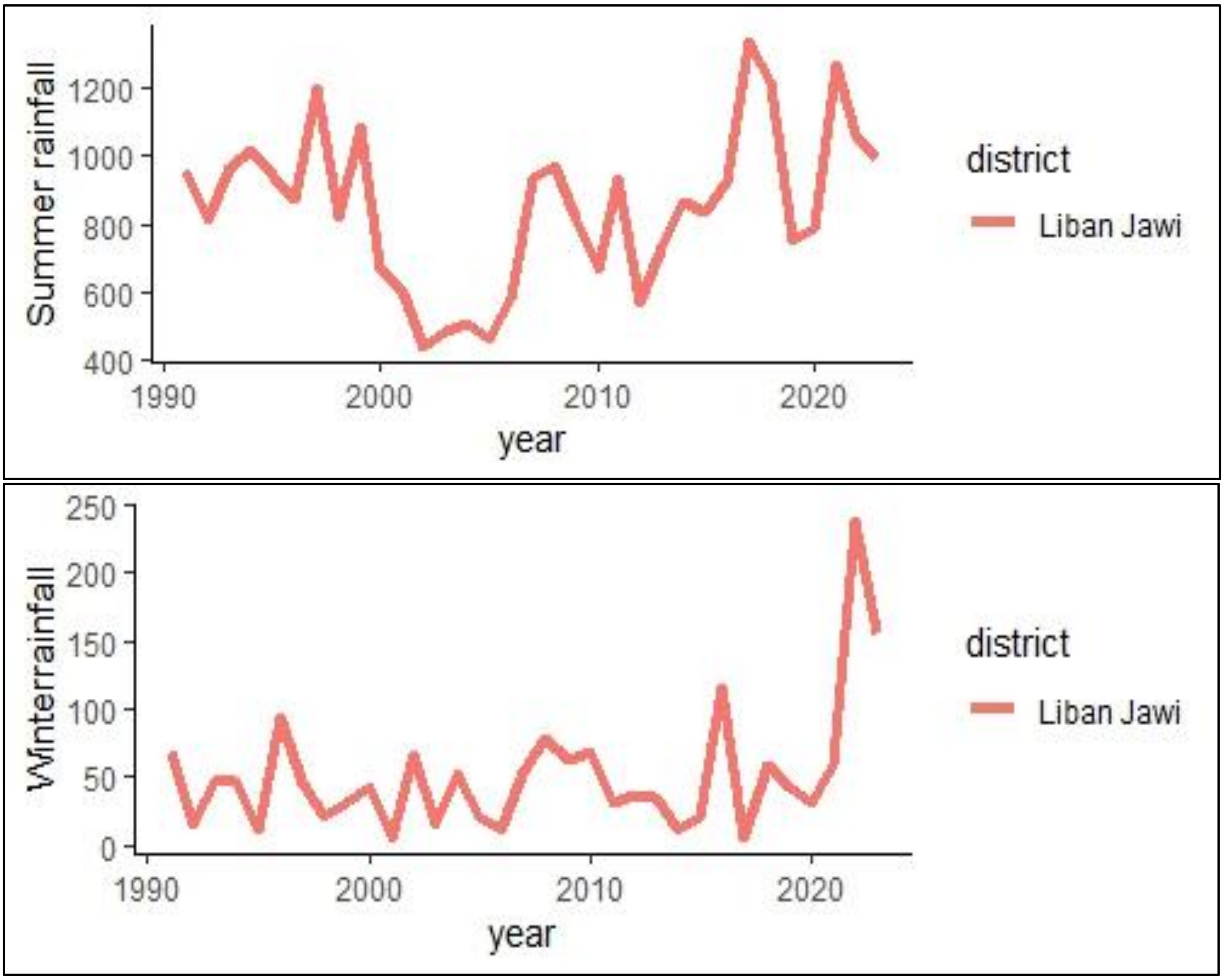

Fig 6 Geometric Line Showing the Trend of Summer and Winter Rainfall Variability (1991-2023)
Source: Generated by Researcher based on Meteorological Data, 2024

Geometric line indicated that there is variability in rainfall both in summer and winter season. Study by (IPCC,2022) showing tmperature extremes are more frequent at dry period of time, where erratic and reduced rainfall during the summer growing season is a growing concern for food security.

The geometric line indicated that there is variability in rainfall in both the summer and winter seasons. According to the IPCC (2022), temperature extremes occur more frequently during dry periods, with erratic and reduced rainfall in the summer growing season posing an increasing threat to food security. Rainfall trend analysis for the Liban Jawi district (1991–2023), covering four seasons and all twelve months, shows a positive Mann–Kendall (MK) Z value, indicating an upward trend. This reflects an annual increase of 16.35 mm in rainfall. The annual precipitation trend is statistically significant at the 0.05 level. The monotonic trend of the rainfall time series was calculated using the MK trend test to determine the exact trend value of rainfall in the study area. The results indicated that seasonal rainfall trends were statistically non-significant for winter, summer, and spring, while autumn and annual rainfall showed statistically significant trends at the 0.05 level for the analysis period (1991–2023).

Table 6 Rainfall Trend Analysis

Seasons (months)	MK statistics (Z value)	Sen's slope (Q value)	P-value	Significance level
Spring (MAM)	0.93	1.99	0.35	NS
Summer (JJA)	0.87	4.42	0.38	NS
Autumn (SON)	**5.58**	**8.29**	0.000023	Significante
Winter (DJF)	**1.33**	**0.53**	0.18	NS
Annual RF	3.015	16.35	0.0025	Significante

ZS: Mk test, Qmed: Sen's Slope Estimator. * Significant Trend at [Zs] > 1.96 (0.05).
Source: Computed Based on Statistical Raw Data of NMSA 2024, for the Period 1991-2023

➢ *Temperature Trend Analysis*

Data was collected and analysed just before the actual study was started to find different statistical parameters like the mean, SD, and CV of the yearly maximum temperature series for the period 1991-2023. Maximum temperature in Liban Jawi varies between 21°C (2002) and 29°C (2016), where the mean annual maximum temperature is 24.7°C with a standard deviation of 0.93°C and a CV of 3.7%. All the statistical parameters for the annual and seasonal bases are shown in the table below.

Winter temperatures are the most stable, showing the least absolute and relative variability (CV=2.2%). Autumn temperatures are the most variable, exhibiting the greatest absolute and relative spread (SD of 1.13). Spring and summer temperatures show moderate variability, with summer being slightly more variable than spring. Mean annual temperature variability falls within the range of seasonal variability, being more variable than winter but less variable than autumn.

These statistics provide a detailed understanding of how consistent or spread out the temperatures are within each period. Lower variability (as seen in winter) suggests more predictable temperatures for that season, while higher variability (as seen in autumn) suggests a wider range of temperature values can be expected.

Table 7 Annual and Seasonal Maximum Temperature Trend

Time series	Mean	Min(year)	Max(year)	SD	CV (%)
Spring (MAM)	24.3	22.4(2007)	26.63(2023)	0.8	3.2
Summer (JJA)	24.54	21.03(2002)	26.7(2018)	0.99	4
Autumn (SON)	25.73	24(1999)	29.3(2019)	1.13	4.3
Winter (DJF)	25.11	23.8(2004)	26.1(2022)	0.56	2.2
Max Annual Tempereture	24.7	24.41(2007)	29.3(2016)	0.93	3.7

Note: SD=Standard Deviation and CV=Coefficient of Variation

Source: Computed based on Statistical Raw Data of NMSA 2024, for the Period 1991-2023

The results of the MK test and Sen’s slope estimator for the maximum temperature of the Liban Jawi district are presented in Table 8. The results indicated rising trends, but not significant in all seasons and annually. The annual average maximum temperature in the study area for the period of analysis showed an increasing trend (Zc value +1.52). The analysis of the mean annual temperature data reveals an increasing trend, but it's not statistically significant. There is a statistically significant increasing trend in winter temperatures; the magnitude of the increasing trend is small for all seasons but pronounced in winter.

Significance of Trend: Winter and spring temperatures show a statistically significant increasing trend. Mean annual, autumn, and summer temperatures do not show statistically significant trends after correcting for serial correlation.

Table 8 Maximum Temperature Trend Analysis

Time series	MK statistics (Z value)	Sen’s slope (Q value)	P-value	Significance level
Spring (MAM)	8.9	0.02	0.00	Significant
Summer (JJA)	0.6	0.004	0.52	NS
Autumn (SON)	0.35	0.003	0.72	NS
Winter (DJF)	2.13	0.014	0.03	significant
Max. Annual Temperature	1.52	0.008	0.13	NS

ZS: MKtest, Qmed: Sen’s Slope Estimator. *Significant Trend at [Zs] > 1.96 (0.05) and NS (Non-Significant).

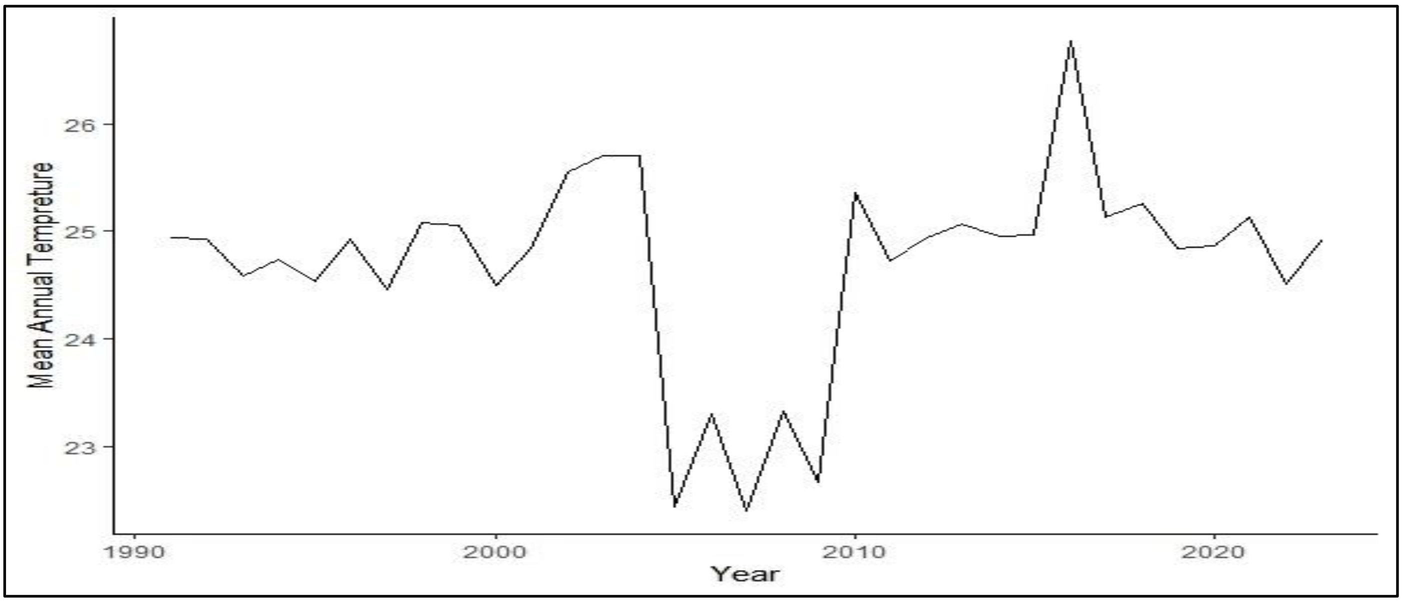

Fig 7 Line Plot of Mean Annual Temperature for Liban Jawi District (1991-2023)
Source: Generated from RStudio Software Based on Temperature Data from the Ethiopian National Meteorological Agency, 1991-2023.

The line plot shows that the temperature in the study area shows a slight increase over time, but it is not statistically significant. This result agreed with my respondents, as the majority said temperature is increasing over time, and some of them also indicated there is a decrease or constant temperature over the study time (1991-2023) in the Liban Jawi district.

- *Farmers' Perceptions of Climate Change and Meteorological Data*

Farmers in eastern Africa perceived that increased temperature as daytime temperatures have increased, leading to faster evaporation and crop wilting, delays in the onset and early cessation of rains affecting sowing schedules, Prolonged droughts and floods, longer dry spells and floods, shorter growing seasons and the manifestation of pests and diseases are factors indicating farmers' perception of climate change and variability in East Africa, including Ethiopia. (IPCC, 2021).

When compared with data from the meteorological centre, it agrees in most cases with farmers' perceptions of climate variability and change. The majority of farmers believed total rainfall increased over the last 30 years in their localities. Meteorological rainfall data analysis was also similar to farmers' perception of rainfall increase in the district. Agro-ecologically, lowland area respondents have perceived a higher increment in temperature than mid-highland area respondents. In Liban Jawi, both the framers' perception and meteorological data indicated an increase in temperature and rainfall in the last 30 years, showing agreement with the findings in Daniel et al. (2014) and previous works by Wagesho et al. (2013) and Moroda et al. (2018).

- *Comparing Qualitative and Meteorological Data*

Considering both KIIs/FGDs and meteorological data, meteorological data also shows a statistically significant increase in both temperature and rainfall over a relevant period (1991-2023), and a summary of my respondents in the focus group discussion and key informant interview confirms that there is an increase in temperature and rainfall; qualitative findings are corroborated. This means the community's perceptions align with the scientific evidence, which strengthens the validity of both qualitative and quantitative data.

- *Common Adaptation Practice in the Liban Jawi District*

Selected respondents in Liban Jawi districts showed different adaptation strategies used by farmers against changes in climate stresses by implementing different adaptation practices like practising mixed farming, soil and water conservation, adopting drought-tolerant and early-maturing varieties, agroforestry practice, and using weather information and forecasting, which are major adaptation practices. (Table 9) Percentages represent the number of farmers in each kebele who reported using the corresponding adaptation strategy. The highest percentage in the total column is 50.5%, corresponding to practising mixed farming, so it is the most prevalent adaptation strategy employed by farmers in the surveyed kebeles. Tulluu Baajoo and Roggee Dannisa have the highest overall percentage (44.88%) and lowest (6%), respectively, of adoption of adaptation strategies in this kebele.

There are variations in the adoption of specific strategies across kebeles. For example, adopting drought-tolerant and early-maturing varieties is used by 10% of farmers in Tulluu Baajoo but only 1% in Roggee Daannisa. Least Common Adaptation Strategies: Using weather information and forecasting has the lowest overall percentage (4.08%). Farmers in the study area are using a variety of adaptation strategies to cope with environmental challenges. Mixed farming is the most common strategy, likely due to its traditional importance and perceived effectiveness in managing risk. The low adoption of weather information and forecasting suggests a potential area for intervention to improve farmers' decision-making and resilience.

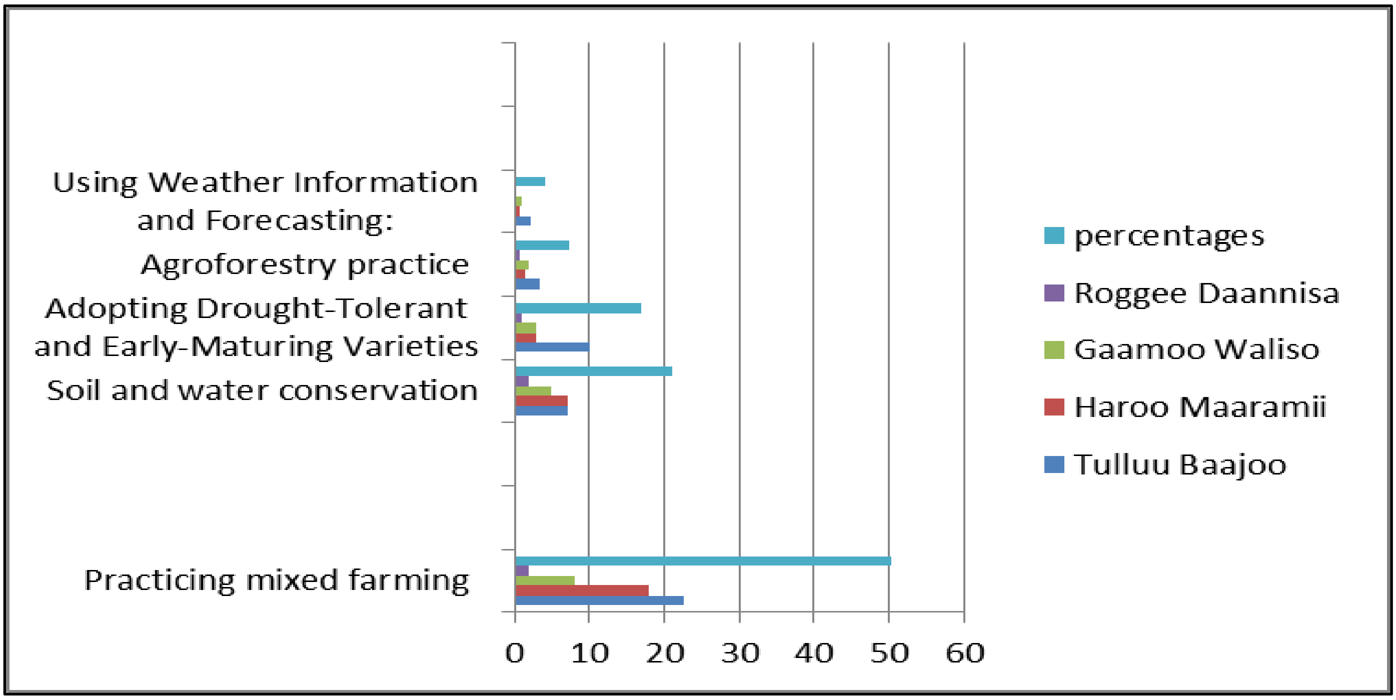

Fig 8 Bar Graph of Kebele-Level Farmers' Adoption of Climate Change Adaptation Strategy

Table 9 Major Adaptation Strategies and Farmers' Response

S.no	Major adaptation strategies	Name of sample kebeles				
		Tulluu Baajoo	Haroo Maaramii	Gaamoo Waliso	Roggee Daannisa	percentages
1	Practicing mixed farming	22.5	18	8	2	50.5
2	Soil and water conservation	7	7	5	2	21
3	Adopting Drought-Tolerant and Early-Maturing Varieties	10	3.01	3	1	17.01
4.	Agroforestry practice	3.3	1.34	1.93	0.75	7.32
5	Using Weather Information and Forecasting*:*	2.08	0.75	1	0.25	4.08
Total		44.88	30.12	19	6	100%

Source: Survey 2024

➢ *Logistic Regression Analysis Result*

It was employed to analyse the determinants of different socio-economic, institutional, and environmental factors that affect farmers' adoption of climate change adaptation strategies. The dependent variable was binary, labelled as 1 = Yes (use/adopt adaptation practice) and 0 = No (do not adopt adaptation practice).

➢ *Model Overview*

A total of 15 predictor variables were entered into the model, including gender, age, education, household size, marital status, training, membership in farmers' associations, membership in savings and loans groups, access to financial aid, off-farm employment, farming experience, cropland size, land tenure, agroecological zone, and government policy.

➢ *Significant Predictors of Adoption*

The regression results (Table 10) revealed that six variables were statistically significant at the 5% level, indicating a meaningful impact on the likelihood of adopting climate change adaptation strategies:

Age (B = 3.169, p = .008, Exp(B) = 23.795): Older farmers were significantly more likely to adopt adaptation strategies. Specifically, for each unit increase in age, the odds of adoption increased by approximately 24 times.

Education (B = 3.806, p = .003, Exp(B) = 44.980): Education level was one of the strongest predictors. Farmers with higher education were about 45 times more likely to adopt adaptation measures compared to those with no formal education.

Household size (B = -0.778, p = .020, Exp(B) = 0.459): Larger household size negatively influenced adoption. An increase in household size reduced the odds of adoption by about 54%. It is because different physical soil and water conservation measures reduce farmland size, which was the case.

Cropland size (B = -2.872, p = .006, Exp(B) = 0.057): Farmers with smaller cropland sizes were significantly less likely to adopt. Each unit decrease in land size drastically lowered the likelihood of adaptation.

Land tenure (B = 3.109, p = .039, Exp(B) = 22.399): Secure land tenure was positively associated with adoption. Farmers who owned their land were about 22 times more likely to implement adaptation strategies.

Agroecology (B = -6.639, p = .005, Exp(B) = 0.001): Agroecological conditions had a significant negative effect. Farmers in mid-highland and mid-highland ecological zones were substantially less likely to adopt adaptation measures when compared with lowland areas, training (p=0.009), membership in farmers' associations (p=0.003), and membership in savings and loans associations (p=0.020).

- *Non-Significant Variables*

Several other variables, including gender, marital status, and government policy, are not statistically significant predictors (p > 0.05). Although some of these factors may play an indirect or contextual role, their effect was not evident in this regression model.

Table 10 Logistic Regression Analysis on Farmers' Adoption of Climate Change Adaptation Strategies.

Farmers' Adoption of Climate Change Adaptation Strategies			
	B	Sig.	Exp(B)
Gender	-1.971	.057	.139
Age	3.169	0.008	23.795
Education	3.806	0.003	44.980
House size	-.778	0.020	0.459
marital status	-.776	0.210	0.460
Training	3.177	0.009	32.5
Membership in farmers association	0.876	.0.003	3.45
Membership in saving and loans associations	-1.934	0.020	0.145
Financial aid	2.904	0.03	15.75
Offarmemployement	8.057	0.04	33.76
Experience in farming	-.345	0.03	0.708
Cropland size	-2.872	.006	0.057
Land tenure	3.109	.039	22.399
Agroecology	-6.639	.005	0.001
government policy	-1.061	.392	0.346
Constant	-123.833	.987	0.000
a. Variable(s) entered on step 1: Gender, Age, Education, household size, Marital status, Training, Membership in farmers association, Membership in saving and loans associations, financial aid, Offarmemployement, Experience in farming, Cropland size, Land tenure, Agroecology, government policy.			

Source: -Computed by Researcher 2025

The result of the study showed that there were positive and negative relationships among the pairwise correlation matrix of adaptation options.

Key variables potentially influencing the adoption of climate change adaptation strategy and the relationship between variables.

Education is positively correlated with membership in farmers' associations (0.41), off-farm employment (0.44), training (0.25), and cropland size (0.20). This indicates that educated farmers are more likely to engage in knowledge-enhancing activities (training, associations), possibly easily adopting new technology, including climate change adaptation strategies.

Off-farm employment is strongly correlated with education (0.44) and membership in farmers' associations (0.26) because off-farm income may increase financial capacity to adopt adaptation strategies like physical soil and water conservation works and establishing nursery sites.

Training correlates with education (0.25) and off-farm employment (0.18), since training is crucial for informed decision-making and related to education and alternative income sources.

Membership in farmers' associations is strongly positively correlated with education (0.41) and off-farm employment (0.26); this can be because associations may provide access to shared knowledge and resources. Some of the variables show weak or negative correlations; for instance.

Age is negatively correlated with training (-0.26) and membership in savings/loans (-0.17), which may indicate that younger farmers may be more proactive or open to change, whereas older ones may not show interest in training and new technologies.

The correlation matrix suggests education, membership in associations, off-farm employment, and training are moderately correlated with each other and could collectively influence adoption of climate change strategies, whereas age shows a negative association with proactive strategies (like training), implying younger farmers may be more adaptable. Land tenure and cropland size have weaker but still relevant associations, suggesting other factors play a secondary role.

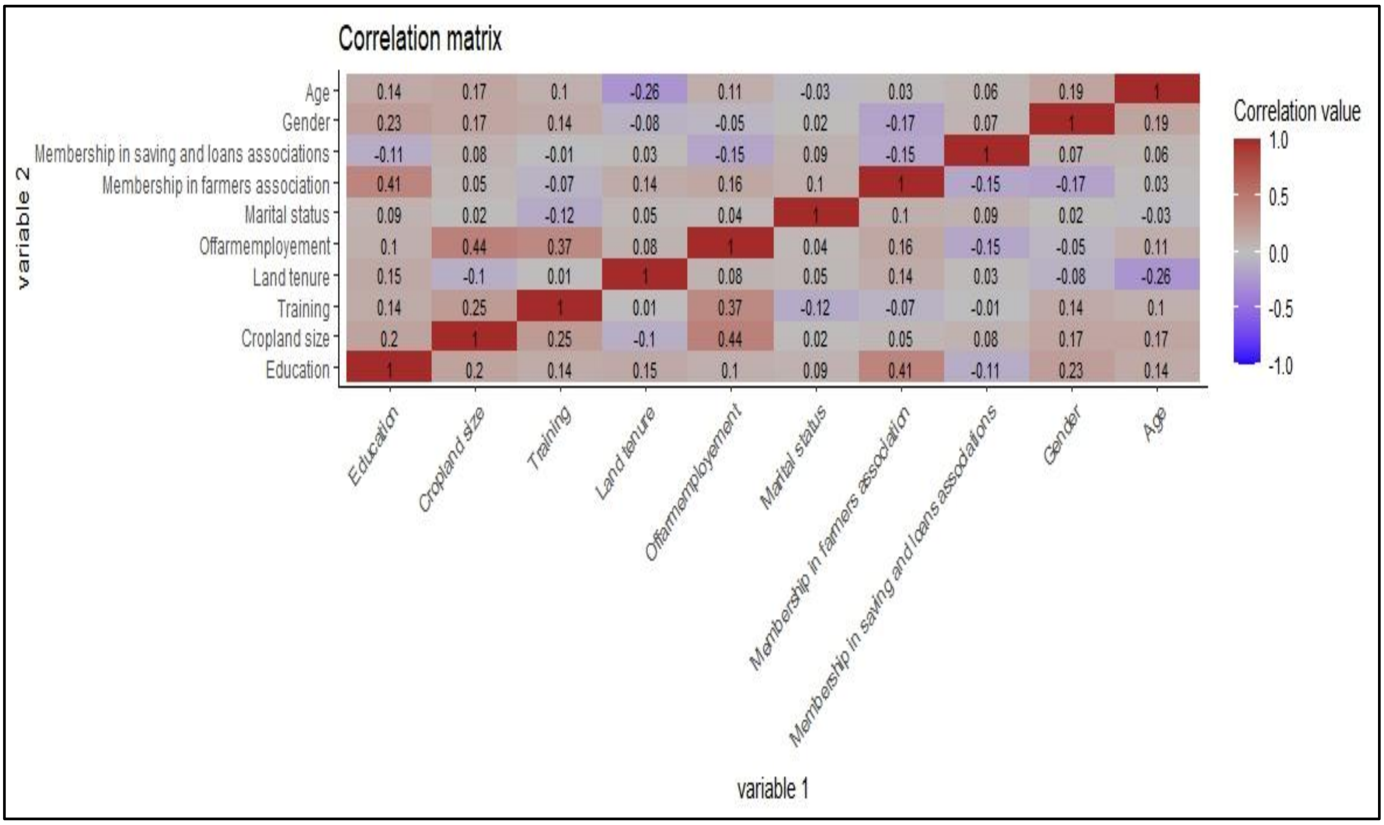

Fig 9 Key Variables Potentially Influencing Adoption of Climate Change Adaptation Strategy and Relationship Between Variables.

Source: Computed by Researcher based on Respondents' Response

Model Statistics shows that Residual Standard Error: 0.2435, R-squared: 0.3893, Adjusted R-squared: 0.3741, F-statistic: 25.5 on 8 and 320 DF, and Model p-value: < 2.2e-16, indicating R-squared: 0.3893. means about 39% of the variability in adoption is explained by my model. Adjusted R-squared: 0.3741 is also slightly lower, accounting for the number of predictors. F-statistic: Significant (p-value < 2.2e-16) shows the result is statistically significant overall at (** p < 0.01 and * p < 0.05).

Table 11 Linear Regression Results — Factors Affecting Adoption of Climate Adaptation Practices

Predictor	Estimate	Std. Error	t value	p-value	Significance
(Intercept)	0.0896	0.1062	0.843	0.0699	NS
Education	0.0355	0.0205	1.736	0.0436	*
Training	0.0208	0.0327	0.637	0.01247	**
Membership in farmers association	-0.0186	0.0508	-0.366	0.0314	*
Membership in saving and loans assoc.	-0.0724	0.0325	-2.227	0.026	*
Off-farm employment	0.3882	0.0350	11.108	<0.001	***
Marital status	0.0045	0.0134	0.340	0.7341	NS
Gender	-0.0148	0.0303	-0.488	0.6259	Ns
Age	0.0481	0.0172	2.803	0.0054	**

*p < 0.05, **p < 0.01, ***p < 0.001

Source: -Source: Own Computation from Survey Data, 2024

- *Discussion of MVP Model Results*

Various explanatory variables were used in this study to assess determinants of climate adaptation practices. Among the listed explanatory variables, the gender of the household head, the education level of the household head, extension contact, access to credit, no/off-farm income, agroecology, government policy, household size, land size, climate change information, and farm experience influenced farmers' adaptation practices positively and significantly. Hence, only those statistically significant explanatory variables are discussed below.

Education level positively affects farmers' adoption of climate change adaptation strategies and is significantly associated with improved crop variety and soil and water conservation activities at a 5% probability level. This is because education creates awareness and helps the farmers to develop positive attitudes towards different adaptation practices like improved crop variety and soil and water conservation as adaptation mechanisms to the change in climate. In addition, education helps farmers to understand and interpret different information. This result is in line with the findings of Seid et al. (2016).

Nhemachena et al. (2014) reported that farmers who have higher extension contacts have better chances to be aware of changes in climatic conditions and also have various management practices that they can use to adapt to climatic conditions.

Access to credit: having access to credit has a direct relationship with and a significant impact on the adoption of farmers' climate change strategies. Farmers having access to credit have a better chance to adapt to strategies for climate variability and change, as it increases the financial resources of farmers and the costs associated with various adaptation options that they might want to take to overcome climate calamities (Leake and Adam, 2015).

On/off farm income: MVP revealed that this variable had a positive and significant influence on the use of the improved crop variety as climate change adaptation practices at a 1% significance level. A plausible explanation for this is that having more sources of income increases the ability of households to purchase improved crop varieties. This result agrees with Seid et al. (2016), who reported that the availability of on/off-farm income improves farmers’ financial position, which, in turn, enables them to purchase farm inputs such as seed and fertilizer.

Membership in farmers' associations and membership in savings and loans associations are strongly positively correlated to the adoption of farmers' climate adaptation strategies because associations and sources of loans may provide access to shared knowledge and resources.

Access to climate change information was found to have a significant and positive influence on farmers’ use of adjusted planting and harvesting dates as coping strategies, at the 1% probability level. This is because such information enhances farmers’ awareness of climate change and equips them with knowledge on various adaptation practices. This finding aligns with Maddison (2006), who noted that access to climate information increases the likelihood of farmers adopting climate change adaptation strategies and practices.

V. CONCLUSION AND RECOMMENDATIONS

- *Conclusion*

My research paper analyzed the trend of climate variability and change, particularly by considering rainfall and temperature in Liban Jawi, based on a literature review, farmers' perceptions, and data collected from the meteorological agency. It also assessed adaptation techniques used by farmers to adapt to climate variability and change and factors that affect farmers' adoption of climate change and variability. Stratified random sampling was used to collect data from local farmers by stratifying Kebele in the District into different agroecological zones and randomly selecting four kebeles from the 15 kebeles of the district, and randomly selected respondents from each kebele were interviewed based on a prepared questionnaire. The purposive sampling method was used to select key informants and focus group discussions with representatives from farmers in the local community. According to the analyzed data of rainfall and temperature that were collected from the Ethiopian National Meteorology Agency, most respondents indicated there is climate variability and change. They raised many indicators for the change, like extreme weather events, expression of precipitation variability, erratic rainfall, decline in productivity, and incidence of pests and diseases. Based on both farmers' perception and data from the meteorological center, a confirmed temperature increase has occurred over the last 30 years. Indicators for this include the average number of hot days and warm nights and cold seasons becoming less cold over time. For rainfall also, both farmers' perception and data collected from the meteorological agency and analyzed on the MK test confirmed that there is an increment of rainfall over time.

As the Mk test analyzed on RStudio indicated, in the Liban Jawi district, annual rainfall had increased by 16.35 mm per year in the study area, and also the minimum and maximum annual temperatures had been increasing during the period of analysis.

Common climate change adaptation practices in the Liban Jawi district, according to respondents, were mixed farming systems, biological and physical soil and water conservation activities, weather information and forecasting, adopting drought-tolerant and early-maturing crop varieties, and agroforestry practices. The result of the Mv probit model has shown that several other variables, including gender, marital status, training, membership in associations, access to financial aid, off-farm employment, farming experience, government policy, and membership in savings and loans groups, were statistically significant predictors ($p < 0.05$). As the impact of climate variability and change significantly affects crop production and productivity based on my findings from different literature, meteorological data and data collected through interviews and focus group discussions in the Liban Jawi district, farmers also used different adaptation strategies that include soil and water conservation, mixed farming, weather information and forecasting, and agroforestry practices to overcome the impact imposed by climatic change. On the other hand, this finding identified that education, family size, landholding size, agroecology, membership in farmers' associations, and membership in saving and loans associations are the important determinants of adaptation practices to overcome the impact of climate change. Enhancing farmer education is crucial for enabling informed decision-making and promoting climate-resilient practices as Securing land tenure can increase farmers' willingness to invest in long-term adaptation strategies.

- *Recommendation*

Based on my conclusion and the results analyzed from primary and secondary data, I would like to strongly recommend the following points.

The Liban Jawi district government, non-governmental organizations, and civil society have to create awareness to increase the local community's understanding of the impact of climate change and to adopt an appropriate climate change adaptation strategy for all concerned stakeholders in the district, starting from the planning to the implementation phase.

The government should mainstream climate-smart agriculture and strategies into sectors like agriculture that strengthen climate change adaptation and mitigation practices in addition to the green legacy and soil and water conservation practices, agroforestry, crop diversification, and rearing of small ruminant livestock that emit low greenhouse gas.

Government and local authorities should work to improve land tenure security to encourage long-term investments in land and soil conservation practices and develop policies that reflect the agroecological diversity of the region to ensure context-specific adaptation support.

Developing network accessibility and early warning systems, and designing targeted training programmes on climate change and its impacts and adaptive farming practices, especially for women and youth.

Promote mixed farming systems and agroforestry practices to build resilience against climate-related shocks.

Promote peer-to-peer learning and farmer field schools to share knowledge on effective adaptation techniques.

Facilitate access to credit and savings institutions tailored to the needs of smallholder farmers to enable investment in adaptation technologies.

Future research should deep dive and investigate how off-farm employment leads to positive outcomes, whether it is primarily through increased income for agricultural investment, reduced pressure on land, diversification of household income, or any other factors.

Support longitudinal research and regular climate data collection to monitor trends and inform future planning by promoting participatory research involving farmers in co-producing knowledge and evaluating adaptation strategies.

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LIST OF ACRONYMS AND ABBREVIATIONS

- FGD: Focus Group Discussions
- CSA: Central Statistical Service
- FAO: Food and Agriculture Organization
- NMA: National Meteorological Agency
- KII: Key informant interview,

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