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# Farmers Choice and Factors Influencing Adoption of Adaptation Strategies to Climate Change in the Case of Abala Abaya Woreda, Wolaita Zone, Southern Ethiopia

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**Abstract**
The study on farmers' choice and factors influencing adoption of adaptation strategies to climate change was conducted in Abala Abaya Woreda, Wolaita zone, southern Ethiopia. The objective of the study is to assess the actual smallholder farmers' choice and adaptation strategies to climate change in the study area. To achieve the objectives, daily meteorological and primary data generated from FGD, key informant such as elder people and employees of Abala Abaya and ADAFPO were used. Abala Abaya was selected purposively. For this study, both simple random and stratified sampling techniques were employed to select the sample of respondent households. Among rural kebeles, four rural kebeles were selected. Out of total population (2166), 94 respondents were included by using Kothari equation and both descriptive and multinomial logistic regression model compared with the base category were used to analyze the data. The results showed that majority of the smallholder farmers employed different adaptation strategies to adapt to adverse effects of climate change including tracing for soil and water conservation, fertilizer application, livestock and crop diversification and using irrigation. The results further revealed that although the local people employed different strategies to adapt the adverse effects of climate-induced shocks, there were constraints that limit the HH's adaptation strategies. These include lack of finance, shortage of land, lack of information and mass media, lack of skill and education and shortage of labor. The MNL model shown that different factors were found to be statistically significant related to terracing for soil and water conservation, fertilizer application, livestock diversification with supplementary feed and using irrigation at $p \leq 0.1$ and 0.05 that is .024, .074, .007, .002, .000 and .006 for education, crop production, livestock ownership, farmers perception to climate change and land size, access to credit and access to market respectively for terracing for soil and water conservation. Access to information was found to be statistically significant related to fertilizer application at $p \leq 0.05$ that is 0.035. In addition to this, size, farming, education and access to market at $p \leq 0.1$ and 0.05 that is 0.074, 0.053, 0.001 and 0.000 respectively were found to be statistically significant related to livestock diversification with supplementary feed.
**Keywords:** adaptation strategies, climate change, factors, and farmers'
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## 1. INTRODUCTION

### 1.1. Background of the study

In the world, especially in sub-Saharan Africa, agriculture fragments the main supplier to socio economic development but the sector is exposed to the effects of climate change and variability. And that this will aggravate in the future as its variability increases (Redda, R. and Roland, R., 2016). Ethiopia is one of the sub-Saharan African countries where agriculture greatly dominates the overall performance of economy. In Ethiopia, rain-fed agriculture is the principal source of food production. As a result, the various impacts of climate change and variability, such as unpredictable rains, droughts, and floods, often overweigh the smallholder farmers of the country (Gebremicael et al., 2019).

Global climate change is deviation in climatic conditions accredited directly or indirectly to human actions that alter the composition of global atmosphere and which are in addition to natural climate variability observed over time periods. Anthropogenic global climate change, as distinct from natural climate variability denotes not only variation in temperature but also rainfall, humidity, cloudiness, and winds. Climate change and variability have stronger impact on subsistence farmer reliant on rain-fed agriculture. It affects agriculture with direct impact on food production and livelihood attributable to natural climate cycle and human activities (Upadhyay P., 2019).

The impact of climate change was experienced in decreasing rainfall, extinction of various species of vegetation, alteration in the nature of weather, humidity and temperature. The situational pressure of climate change influenced the customary ways of living; livelihood efforts were being harder, perceived and experienced in daily life. Unseasonal, erratic and decreasing rainfall, rising temperature resulting in summer drought, and oddly low temperature and cold waves during winter, was affecting agriculture and biodiversity. Farmers were in constant trauma of water scarcity. Water sources were drying up with reduction in underground and river water level and wet-land was becoming arid (Upadhyay P., 2019 and FAO, 2015).

For the farmers, survival was the concern, adaptation as interaction with nature reproduced through practices prioritized that were socially constituted and culturally meaningful/pragmatic and were constructed through compulsive adaptation practices for sustaining agro-production and livestock for greater productivity. Farmers' knowledge and skills of their environment and its relationships with social systems formed key elements of their updated and modified adaptive culture, capacity and identity to cope climate change impacts. Understanding the interactions of culture and climate, and in meticulous the role of perceptions, knowledge, and values as elements of interactions, brought farmers to focus on adaptive responses (FMoH, 2018).

Farmer's responses to climate variability consisted of iterative succession of improvised strategic adjustments. Based on their expectations of what the climate might be, farmers proceed to carry out agricultural practices. Moderately, they get their demeanors by analyzing the environment during the weeks and months that lead up to the beginning of the rains, and continue to do so until the feasible planting time, a process that depend on a mix of sensory insight, cumulative experience, learned skills and media information(Upadhyay P., 2019 and FMoH, 2018).

Broadly, climate change as an issue has played an increasing role in reinforcing and shifting farmers positions allowing them better understanding and adaptation to changing climate in order to manage it in better ways for their and community benefit. Human have contributed to climate change through land use changes, burning of fossil fuels and natural factors such as change of solar radiation, volcanic eruption, greenhouse gas, and the earth's orbital change. The national economy and food security are highly dependent on rain-fed agriculture (FAO, 2015 and FMoH, 2018).Therefore, this study play an important role to assess the actual smallholder farmers' choice and adaptation strategies to climate change in the study area.

### 1.2. Statement of the Problem

Climate change impact is perceived to contribute in raising temperature, agro-production decline and emergence created negative impact on agriculture and livelihood. Without any external support, accentuating collective experiences based on cultural framing, the local farmers' fashioned integrated adaptation strategies, updated the indigenous practices to agricultural diversification by altering crop cultivation period, adopting alternative crops, hybrid livestock, dairy co-operative and micro credit services. The per formative integrated adaptation practices visualized on cultural valuation and responses mediated farmer's engagements with natural phenomenon and framed the ways they observed, understood, experienced and cope-up to climatic variations hence confirming that agriculture and livelihood adaptation is obviously a socio-cultural technical process(Upadhyay P.,2019 and NPC 2016).

Ethiopia is one of the least developing countries in which majority of its population depend on agriculture sector. Rising the agricultural production at the national level leads to improve overall economic growth and development. However, currently climate variability has become a serious threat to sustainable economic growth. Backwardness, poverty, drought and high level of dependency on subsistence agriculture have limited the climate change coping capacity of a large bulk of local farmers. Current climate variability is already imposing a significant challenge to Ethiopia by affecting food security, water and energy supply, poverty reduction and sustainable development efforts, as well as by causing natural resource degradation and natural disasters (ATA, 2017).

From climate science perspective, localizing is the process of downscaling from global climate models to specific places, accommodating local risk perceptions, experiences, vulnerability, adaptation and the inability of top-down methods to address local farmer's concerns- climate change impact on their food production and livelihood security. Climate system is mostly altered by human being and the change in climate poses risks for humanity (NPC, 2016).

Empirical studies related with climate change in different parts of Ethiopia cannot be implied for other specific areas due to adaptation strategies vary contextually and spatially within communities and even among individuals (Ibid). The capacity to adapt to climate change is unequal across and within societies and understanding of the local dimensions of the climate variability is important to develop appropriate adaptation measures and appropriate policies in order to minimize and cope with the problems of climate change. Adaptation responses are also underpinned by common enabling factors as there are individuals and groups within all societies that have insufficient capacity to adapt to climate change and addressing adaptation practices to specific societies or communities may make it possible to offset the adverse impact of climate change.

Different researches conducted in Ethiopia has a methodological gap in addressing the choice of climate change adaptation strategies as they used multinomial logit (MNL) model to identify factors affecting choice of adaptation strategies to climate change. MNL model assumes that a farmer faces a set of discrete, mutually exclusive adaptation options from which a farmer chose exactly one adaptation strategy. Farmer may choose more than one adaptation strategy at a time and identified adaptation option can be interdependent. Consequently, there was a need to undertake a research at household or farm level in different areas of Ethiopia which are very essential to know micro level farmers‟ perception to climate change, identifying adaptation strategies and identifying determinants using multinomial logistic model which helps to design appropriate strategies in that local context.

 

No empirical study has been conducted to examine the actual smallholder farmers' choice and adaptation strategies to climate change in the study area to date to the best of the researchers‟ knowledge. Therefore, this study intended to fill the gap of farmers' perceptions about risks associated with climate change, factors influencing the choice of climate change adaptation strategies and evaluate the climate change which has been experienced by the rural farmers in Abala Abaya.

### 1.3. Research objectives

#### 1.3.1. General Objective

- The general objective of the study is to assess the actual smallholder farmers' choice and adaptation strategies to climate change in the study area.

#### 1.3.2. Specific objectives

- To assess farmers' perceptions about risks associated with climate change in the study area
- To analyze factors influencing the choice of climate change adaptation strategies
- To evaluate the climate change which has been experienced by the rural farmers

### 1.4. Research Questions

- What are the factors influencing the choice of climate change adaptation strategies in the study area?
- What will the evaluated climate change which has been experienced by the rural farmers in the study area looks like?
- What are the farmers' perceptions about risks associated with climate change in the study area in the study area?

### 1.5. Scope and limitation of the study

This study was conducted in Abala Abaya Woreda, in Wolaita Zone of Southern Ethiopia. The study mainly investigates the actual smallholder farmers' choice and adaptation strategies to climate change in the study area. For this study the scope was limited with respective to the stated objectives above. Thus, this study concentrates on farmers' adaptation strategy choice to climate change in the area and factors that influence adaptation strategies.

### 1.6. Significance of the study

Different researchers have studied farmers' adaptation strategy choice to climate change in the area and factors that influence adaptation strategies in the world as well as in Ethiopia. None of them have studied farmers' adaptation strategy choice to climate change in the area and factors that influence adaptation strategies. Hence, the result of this study provide the farmers' perceptions about risks associated with climate change, factors influencing the choice of climate change adaptation strategies and evaluate the climate change which has been experienced by the rural farmers in Abala Abaya. The study give clue direction for climate change problems and then to develop mitigation and/or adaptation strategies to overcome the emerged problems. Henceforward, the study identifies appropriate adaptation strategies employed by smallholder farmers' and design necessary strategies to implement accordingly to reduce influence on. Finally, the study is taken as a base for further study in the area of climate change and its adaptation in the study area.

## 2. LITIRATURE REVIEW

### 2.1. Climate Change in the world and Roles of Adaptation

Nowadays, climate change is acknowledged as one of the most challenging and complex problem confronting the agricultural development worldwide (Tesfahunegn et al. 2016). However, agricultural production activities in Africa are generally more vulnerable to climate change than any other socioeconomic activities (Burnett 2013; Elumet al.2017; IPCC 2014). It is predicted that agricultural production in Africa will decrease by 8%– 22% by 2050. The continuous dry seasons experienced throughout the recent 30 years and the ongoing effects of El Niño in East African nations in general and Ethiopia specifically, made food insecure to large number of people because of climate change (Yayeh, 2017).

Climate Change Observations in Ethiopia Given the range of negative impacts of current climate (and non-climate) hazards on pastoralist and agro-pastoralist livelihoods, the implications of climate change must be taken into account to ensure longer-term survival and sustainability of these communities. This requires an appreciation of how the climate has already changed in recent decades and what is projected to change in the decades to come. According to the UNDP Climate Change Profile for Ethiopia, the mean annual temperature in Ethiopia has increased by 1.3°C between 1960 and 2006, at an average rate of 0.28°C per decade (NPC ,2016).

The rate of increase is seen most strongly in June, July and August. Over the same period, the average number of cold days and nights decreased by 21 (5.8% of days) and 41 (11.2% of nights), respectively. These reductions have mainly occurred in the months of September to November. It is very difficult to detect long-term rainfall trends in Ethiopia, due to the high inter-annual and interdecadal rainfall variability. Between 1960 and 2006, no statistically significant trend in mean rainfall was observed in any season. The decrease in rainfall observed in July to September in the 1980's recovered in the 1990s and 2000s. In addition, there are insufficient daily rainfall records to identify trends in daily rainfall variability and changes in rainfall intensity (FAO, 2016).

According to the National Meteorological Agency, Ethiopia experienced 10 wet years and 11 dry years over the last 55 years, demonstrating the strong inter-annual variability. The wet years included 1958, 1961, 1964, 1967, 1968, 1977, 1993, 1996, 1998 and 2006. Dry years were 1952, 1959, 1965, 1972, 1973, 1978, 1984, 1991, 1994, 1999, and 2000 (NAPA, 2007). Ethiopia has contributed very low to the current climate change. Per capita GHG emissions of Ethiopia has been estimated 900kg CO2 equivalent which can be compared to U.S. emissions of 23.7 tonnes CO2 equivalent per capita and year in 1994. Much of the emission in Ethiopia is accounted to the agriculture sector which is about 80% of the total GHG emissions. Sector wise, Ethiopia's GHG emissions are dominated by agriculture, which contributes 80% of the total GHG emissions. This reflects the fact that livestock farming goes together with high methane emissions. The dominant position of livestock farming in Ethiopia's economy also influences the relative contribution of GHG to the total emissions. These are dominated by methane emissions, which account for 80% of the warming potential (EPCC, 2015).

## 2.2. The Impacts of Climate Change in Ethiopia

### 2.2.1. Impacts on Agriculture

Ethiopia confronted many adverse impacts which are manifestations of variable climate. Yet there are indications by which these impacts will continue to influence the socio-economic activities of the community at larger scale. The northern, southern and south-eastern dry land regions of Ethiopia have repeatedly faced increased frequency of meteorological drought episodes, famines and outbreaks of diseases which are believed to be linked with climatic change. The droughts have highly impacted the agriculture of the country and brought about the loss of crops, animals and above all the loss of millions of people. Flood hazards have increased in recent decades. The flood hazards which have occurred in different parts of the country in 1988, 1993, 1994, 1995, 1996 and 2006 are such indications. These flood hazards have demanded in crop and animal destructions as well as human lives (IPCC, 2014).

Despite the fact that the effects of climate change differ temporally and spatially, the threat to rain-fed agriculture is viewed as the most pervasive as future effects are expected to exacerbate following alteration in rainfall and temperature (Deressa et al., 2011; Kurukulasuriya and Mendelsohn, 2008). Also, climate change is probably going to have an overall negative impact on the yields of main cereal crops (Deressa et al. 2008; IPCC, 2014). As indicated by certain studies, climate change would even disrupt individuals' daily activities, alter growing seasons, cause a decrease in crop yield and biomass production and increase risk of food insecurity. Rural farmers in low-income countries feel the adverse effects of climate change more severely (Burnett, 2013; Deressa et al., 2008; IPCC, 2014; ISET, 2013).

Many studies have concluded that the agriculture sector of the country is the most affected sector by climate change. Deressa et al., (2011) made an integrated quantitative vulnerability assessment for seven Regional States of the total eleven regions by using biophysical and social vulnerability indices of Ricardian approach. The study revealed that decline in precipitation and increase in temperature are both damaging to Ethiopian agriculture

### 2.2.2. Impacts on Crop Production

The yield effects reflect the reductions in yield due to either the lack of available water, or due to the overabundance of water that causes water logging. The impact of these trends tends to grow stronger in time. The impacts of climate on yields are first-order effects that trigger direct and indirect economic impacts - such as reductions in income, employment, savings and investments. The effects of climate change on the different crops are weighted averages across regions, using the regions' shares in crop total production as weights. Baseline yields include a technology growth component reflecting historical trends (World Bank, 2011).

According to Kide (2014) studies that have investigated impacts of climate change in the context of Ethiopia using a Ricardian approach, find that the climate variables have a significant impact on net crop revenue per hectare of farmers under Ethiopian conditions. Their results also indicate that the net revenue impact of climate change is not uniformly distributed across the different agro-ecological zones of Ethiopia. However, these studies looked at the impacts of climate change on crop agriculture only. Hence, climate variability/droughts have impacted seriously on the country over the past ten years, resulting in increasing agricultural losses and human suffering as shown in Table-1, placing the country in a situation of critical food insecurity and water shortages.

Table-1. Impact of drought on people and crop production over the last ten years (1994-2004)

| Years | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Crop yield (t/ha) | 10 | 12 | 12 | 11 | 11 | 11 | 10 | 13 | 9 | 14 | 14 |
| People affected (millions) | 6.7 | 4 | 2.8 | 3.4 | 4.1 | 7.2 | 10.6 | 6.6 | 7.7 | 13.2 | 7.2 |

Source: Mathewos Hunde, 2004

**2.2.3. Impacts on Livestock production**

Although the direct effects of heat stress on livestock have not been studied extensively, warming is expected to alter the feed intake, mortality, growth, reproduction, maintenance, and production of animals. Collectively, these effects are expected to have a negative impact on livestock productivity (Thornton et al., 2009 cited in EACC). Chickens are particularly vulnerable to climate change because they can only tolerate narrow ranges of temperatures beyond which reproduction and growth are negatively affected. Further, increases in temperature caused by climate change can be exacerbated within enclosed poultry housing systems. The Economics of Climate Change Adaptation study uses survey data from Seo and Mendelsohn in 2006 (Buchhorn et al., 2020).

Angassa (2007) study reconstructed 21 years of household cattle population data in key resource and nonkey resource (pond-water) rangelands in southern Ethiopia, to analyze the relationship between long-term rainfall and cattle population dynamics. The evidence of density-dependence was relatively important at the local land use level as compared with the regional level. Cattle population below carrying capacity under ranch management did not reduce herd die-offs, suggesting that rainfall variability, not density, had greater influence on cattle population dynamics. The evidence that droughts were more harmful to breeding females and immature animals than to mature males suggested that drought management needs to focus on herd recruitment potential. The amount and duration of rainfall is declining and the dry season is becoming longer, which has led to shortage of water and pasture, spread of human and livestock diseases, and intensification of conflicts. Prolonged drought has led to the loss of livestock assets, and it has become difficult to restock. Usually during drought, as the animals have less access to pasture and become weak, they are more susceptible to different diseases when they are concentrated around a few water points (Ojo T. and Baiyegunhi L., 2018).

**2.2.4. Impacts on Agricultural GDP and GDP Growths**

Studies show that decrease in rainfall and increase in temperature both affect agriculture of the country (Deressaet al., 2011). The trends in the contribution of agriculture to the country's total GDP clearly explain the relationship between the performances of agriculture, climate and the total economy. Years of drought and famine (1984/1985, 1994/1995, 2000/2001) are associated with very low contributions, whereas years of good climate (1982/83, 1990/91) are associated with better contributions (CEEPA, 2006 and Simane et al., 2016).

**2.2.5. Impacts on Food Availability**

Because of irregular rainfall and droughts the country is experiencing deficits in food production in several areas, and likely increase in acute weather events, amplified aridity and a decrease in precipitation, range resources and soil moisture will escalate the situation. The shortage of water which is supposed to happen due to climate change will highly impact the already water stressed lowland regions and agricultural activities may no longer be successful. The availability of food has become a major bottleneck for millions of households in many parts of Ethiopia due to the repeated drought cycles and disparity in rainfall. This has been evidenced that when the rainy seasons are normal the amount of food aid decreases and vice versa. Agro-pastoral and pastoral households, which are reliant on livestock for their livelihoods, also suffer severe asset losses during droughts (World Bank, 2007 and Buchhorn et al., 2020).

**2.2.6. Impacts on Water Resources**

Home to twelve major river basins, Ethiopia is rich in water resources and is considered to be the "water tower" of Northeast Africa. Yet extremely limited water storage capacity prevents the country from capitalizing on these abundant water resources. Climate change is expected to reduce run-off to Nile tributaries (Abay and Awash Rivers) by up to one-third. Decrease in river run-off has important consequences for flow into hydropower generation. In addition, climate change is expected to lead to drying of wetlands with severe implications for key breeding sites of some bird species (World Bank, 2011). According to NAPA (2011) the water resources sector will be affected by climate change through a decrease in river run-off, a decrease in energy production, as well as increased floods and droughts (the case of Haramaya Lake is notable example). In general discrepancy of the rainy season, which emanates from climate variability, results in water shortage. Consequently, the ecosystem, which is the source of rain and water resource, will be affected. Rainwater scarcity would affect the aquatic life by deteriorating the quality and quantity of a water body. For instance, water insufficiency endangers the fish resource, which is the cheap source of protein and leads to food shortage. In general, development activities based on water will be deteriorated as a result of water deficiency.

**2.2.7. Impacts on Health**

Warmer temperatures and variations in rainfall patterns associated with climate change are already altering the transmission mechanisms of water- and vector-borne diseases in Ethiopia. Incidence of malaria, dengue fever, and water-borne diseases (e.g. cholera, dysentery) is likely to become more prevalent, while food insecurity related to extreme events also threatens the lives and livelihoods of millions of Ethiopians (NAPA, 2007). The NAPA cites the migration of malaria carriers to highland areas as the predominant risk to the human health sector. Malaria already accounts for up to 20% of deaths of children under five years of age. During years when epidemics prevail, mortality rates of nearly 100,000 children are not exceptional. The last serious malaria epidemic occurred in 2003; up to 16 million cases of malaria were detected, 6 million more than those in an average year (UNICEF, 2011). Minor shifts in geographical presence of malaria could expose millions to infection (e.g. in densely populated areas of east African highlands) (IPCC, 2014). Rainfall also plays a role in determining the availability of mosquito habitats and the size of mosquito populations.

In a 2004 study (McMichael et al.,2004) it was calculated that 36,000 lives were already being lost each year across Eastern Africa (including Ethiopia) because of climate change. The same study calculates that the greatest future health risks associated with climate change in 2030 will be flooding, followed by malaria, diarrheal disease, malnutrition and cardiovascular diseases. According to the World Bank (2011), 68% of Ethiopians are already living in areas at risk from malaria, where transmission is unstable and characterized by large scale epidemics. For example, in 2003 large scale epidemics resulted in 2 million confirmed cases and 3000 deaths. The 4th report of the IPCC states that by the 2050smalaria will have entered into the highland areas of Ethiopia and that by 2080 conditions will be highly suitable for malaria transmission. To avoid future health risks associated with climate change, it will be necessary to organize and implement community-based health education programs in order to raise awareness and educate local population about the importance of personal hygiene and environmental health management (Belay et al., 2017).

#### 2.2.8. Impacts on settlement and infrastructure

Climate variability, including extreme events such as storms, floods and sustained droughts, already has marked impacts on settlements and infrastructure (Freeman and Warner, 2001). Negative impacts of climate change could create a new set of refugees, who may migrate into new settlements, seek new livelihoods and place additional demands on infrastructure (IPCC, 2014). Impacts on settlements and infrastructure are well recorded for recent extreme climate. For instance, the devastating flood in August 6, 2006 caused death of 256 people, displaced 9956 and 244 people missing. The flood has made 2685 households homeless. Out of the displaced people, 5524 are in temporary shelter while 4432 living with their relatives and friends. The flood has inflicted huge damages on urban infrastructures (Table 2). Roads, bridges and houses were destroyed. Electric poles, water pipes and sanitation facilities were also damaged.

Table 2. Impact of climate change on infrastructure

| S.N. | Damage on urban infrastructures | Estimated cost of damage (Birr) |
|---|---|---|
| 1 | The rehabilitation of Dechatu main bridge, which was done few years back by 2.4 million birr (from the previous damage) | 3,000,000.00 |
| 2 | Taiwan Irish crossing that joins Taiwan with Number-1 area. | 900,000.00 |
| 3 | Halfkat Irish crossing which connects Halfkat and Vera pasta areas | 500,000.00 |
| 4 | Dechatu retaining wall in two parts (60m) | 400,000.00 |
| 5 | Kefira guide wall about 120m has been destroyed | 950,000.00 |
| 6 | About 100m retaining wall along Goro River in GTZ settlement area | 930,000.00 |
| 7 | All the roads with in the radius of 40m from Dechatu River bed covered by silt brought by the flood | 517,100.00 |
| 8 | Electric poles and lines | 500,000.00 |
| 9 | Telephone poles and lines | 6,098.36 |
| | Total | 7,703,198.36 |

Source: DDAEPA (2011)

### 2.3. Causes of Vulnerability to Climate Conditions in Ethiopia

Generally, Ethiopia is vulnerable to the impacts of climate change because of interlinked several factors: poverty, recurrent droughts, high population growth, inequitable land distribution, over exploitation of natural resources, subsistence rain-fed agriculture, etc. Ethiopia is above all vulnerable to climate change as a consequence of its landscape variability, low income, and bigger dependence on climate susceptible socio-economic sectors such as agriculture, pastoralism and natural resources. Hence, it is very critical to consider the vulnerability of Ethiopia to climate change impact is a function of several biophysical and socioeconomic factors (IPCC, 2014).

With the very nature of agricultural productivity and natural resources management has much to do with the climate of Ethiopia. Particularly the observed changes in the two parameters of climate, viz. temperature and rainfall have affected the agriculture and livelihoods of the people. The vulnerability is amplified by inadequate and unaffordable agricultural inputs, landlessness and unemployment, and water shortage. Climate change also indirectly affects agriculture by influencing emergence and distribution of crop pests and livestock diseases, exacerbating the frequency and distribution of adverse weather conditions, reducing water supplies and irrigation, and enhancing severity of soil erosion (Watson et al., 1998; IPCC 2001). The key climate induced vulnerabilities of households in the lowlands are shortage and variability of rainfall, decline in crop production, chronic water shortages, floods, livestock and human diseases, conflicts over pasture and water, and livestock and crop price fluctuations (Belay et al., 2017).

In the highland areas the main climate-related vulnerabilities relate to erratic rainfall, drought, hailstorms, frost, strong winds, land degradation, and pests and livestock diseases affecting crop and livestock production (Belay et al., 2017). Overall, climate variability and climate change will adversely affect crop yields, resulting in income fluctuations and declining food security (World Bank, 2007). According to ATA (2017) study on assessment of the vulnerability of Ethiopian agriculture to climate change and farmers' adaptation strategies based on the integrated vulnerability assessment approach using vulnerability indicators.

Some reasons can be mentioned:

- high dependence of the livelihoods of most people on rain fed agriculture (it is tremendously reliant on the timely start, amount, duration, and distribution of precipitation)
- traditional system of agriculture with low use of input and obsolete farm implements,
- low an inefficient use of irrigation as compared to the potential of the country,
- In addition highlands, land area that accounts for only 45% of the country account for over 80%of the total population and for 95 percent of the cropped land, and has been suffering from widespread erosion, overgrazing, deforestation and loss of nutrients and consequently reduced per capita share of arable land (Ojo T. and Baiyegunhi L., 2018).
- high reliance of the population on natural resources and climate sensitive livelihoods, and high dependence on natural resources which are highly affected by environmental degradation
- the existence of extensive poverty
- Over 90% of the food supply comes from rain fed subsistent agriculture and rainfall failure means loss of major livelihood source that always accentuate food deficit(Ojo T. and Baiyegunhi L., 2018).
- The limited economic, institutional and logistical capacity to adapt to climate change, etc. Predictions indicate that the country will be challenged by impacts of climate change such as droughts, floods, strong winds and heat waves (high temperatures), frosts, pests and diseases affecting livelihoods and health of the people and the natural ecological systems. The country's major economic sectors including water and range resources, food security, biodiversity and human and animal health are vulnerable to current climate variability, and will be affected even more by future climate change (Ojo T. and Baiyegunhi L., 2018).

### 2.4. Climate Change Adaptation in Ethiopia

Adaptation refers to "adjustments in ecological, social or economic systems in response to actual or expected stimuli and their effects or impacts. Depending on its timing, goal and motive of implementation, adaptation can be reactive or anticipatory, private or public, planned or autonomous. Adaptations can also be short/long term, localized or widespread (IPCC, 2014). Adaptation measures are very specific to a particular location and situation. What might work in one place or within one socio economic group may not be feasible elsewhere. The reason for this might be among other different agro-ecological zones, different climate and different assumption for adaptation (Buchhorn et al., 2020).

Awareness and adaptation to climate related hazards are influenced by the experience in prolonged climate hazards such as higher mean temperature and lower precipitation. In many instances, households are aware of some of the climate related hazards they are facing and their consequences and as a result they have developed strategies to deal with such hazards. Identifying the key adaptation strategies and factors explaining household's choice of a particular climate adaptation strategy is important for designing and/or scaling-up interventions for better climate adaptation (ATA, 2018).

The main adaptation strategies in the lowlands include livestock sales and slaughter; inter household support, casual labour employment and migration, change in herd composition, reducing expenditure on nonessentials/non-food items, reducing food consumption, livestock migration, increase in firewood/charcoal sales, increasing wild food consumption, loping trees for fodder, seeking food aid rations in towns, digging wells at river banks (SC-UK/DPPFSB/DPPA, 2008; SC-UK/DPPA, 2008). Adaptation strategies specific to Afar and Borana pastoralists include income diversification through migration to nearby towns or through labor hiring for herding livestock of the well-off absentee pastoralists, changing herd composition by increasing the size of camel and sheep, livestock sales, opportunistic crop production as well as planning use of water through traditional water administration committees (Belay et al., 2017).

It is also indicated that loping evergreen trees to feed animals, consumption of wild plants and building assets through constructing houses in the nearby towns in good years is also among the adaptation strategies for cash earning during periods of climate hazards. In highland areas, important adaptation mechanisms include planting disease and drought resistant short cycle crops, labor migration (no. of migrant household members and duration varies with severity of the stress), firewood/charcoal sales, livestock sales and agricultural wage labor. Related responses include reduction in expenditure on non-essentials, reduction in educational expenses, increase in school drop outs, remittances from relatives, and reduction in frequency and size of meals (LIU/DMFSS, 2009). ATA (2014) identified the use of various crop varieties, tree planting, soil conservation, early and late planting and irrigation as the main climate adaptation strategies in the Nile Basin of Ethiopia.

Household choice of a particular climate adaptation strategy can be influenced by the resource demands (e.g. labor, other inputs) the strategies pose. According to ATA (2014), important determinants of farm level climate adaptation in the Nile basin of Ethiopia include the level of education, access to extension, information on weather data, diversified agriculture and social capital. It also shows that an increase in household wealth (indicated by farm and farm income and livestock holding), level of education, age and family size increases the likelihood of climate change awareness and adaptation.

According to ATA (2017), study indicates that wealth is important for climate awareness and adaptation, the question, however, becomes whether there is a potential reverse causation running from adaptation to wealth such that adaptation also leads to increased wealth. Specifically, where non-farm income is considered among wealth indicators, there is a question of whether labor income, e.g. through labor migration, is an adaptation strategy itself or an outcome of other adaptation strategies. The same question applies to livestock holding as wealth indicator. Identifying the determinants of adaptation with proper caution (e.g. through proper econometric procedures or use of exogenous wealth indicators), would help to identify between different vulnerability groups/households for further analysis.

Moreover, male headed households are reported to have a higher likelihood of adoption of adaptation strategies which raises the question of whether climate adaptation strategies are gender specific. The positive adaptation effect of being male headed and an increase in family size are indicators that climate adaptation strategies may be more labor demanding. The study furthermore shows that a lack of information on climate change impacts and adaptation options, a lack of financial resources, and labor and land constraints explain why no adaptation is adopted among the farmers. An important component of factors explaining farmers' choice of adaptation strategies and the degree of adoption of a particular strategy is the cost associated with the particular strategy. Hence, designing a framework for costing and estimating the cost associated with the adaptation strategies is relevant in the effort towards addressing climate adaptation issues among the most vulnerable groups (IPCC, 2014).

#### 2.4.1. Adaptation at household level scale

In the drier areas of Ethiopia, cropping is largely difficult and certainly risk full with both regards to production and environmental degradation. In those areas, livestock production is the major source of income. CEEPA (2006) stated that, owning livestock might buffer the farmers against the effect of crop failure or low yields during harsh climatic conditions. If the farmers have these types of resources, it may function as an important safety net and contribute to extra income, because animal products and livestock can be sold during difficult periods. Selling of livestock is identified as a coping mechanism to climate variability and extremes in Ethiopia (ATA, 2017).

##### 2.4.1.1. Off-Farm Activities

Farmer's vulnerability to climate change can be mitigated if they have off-farm work on the side. Abidet al., (2015) found that sale of labor was a successful coping strategy among farmers in the Upper Awash Basin of Ethiopia during drought periods because it reduces dependency on agriculture. Traditional and contemporary coping mechanisms in Ethiopia also include increased petty commodity production. Off-farm activities can for instance be selling of honey, or homemade products like mattresses, hot food, beverages, and ropes. Where opportunities exist, working as wage laborers and trading commodities are also common in Ethiopia (Belay et al., 2017).

##### 2.4.1.2. Selling of Assets

Sale of agricultural tools and other assets are identified as coping mechanism to climate variability and extremes in Ethiopia. Farmers may sell some of their resources, and this can be an important extra income and can function as a safety net and a coping mechanism. Material assets within the household can be seen as buffer against difficult periods (Kide, 2014).

#### 2.4.2. Adaptation by community

##### 2.4.2.1. Tree Planting

Abidet al., (2015) identified that, tree planting to be one of the major methods used by farmers to adapt to climate change in the Nile Basin of Ethiopia. Vegetation like trees and grass are valuable because the roots protect the soil from erosion. Trees are valuable during floods and droughts, and many trees together will give lower temperatures in the near area, a fresh air, and shadow.

##### 2.4.2.2. Soil and water conservation

One of the adaptation strategies found in Yayeh research in the Nile Basin of Ethiopia was soil conservation. Many areas of Ethiopia are mountainous and crop fields are rarely flat. Often they are located in a hillside or in a valley side. This creates extra demand for soil and water conservation to prevent the soil and rainwater from being washed away. Terraces are often built together with soil bunds, stone bunds, deep trenches, and special rainwater harvesting methods. Those are the most common strategies to conserve soil and water in the field. Soil and water conservation strategies are mainly used because of soil degradation and soil erosion, and because farmers due to this, want to rehabilitate their fields. Today these activities are increasingly important because climate change to some extent is accelerating these processes (Yayeh, 2017).

**2.4.3. Introduced adaptation by institutions**

**2.4.3.1. Crop diversification**

Crop diversification is well known in sub Saharan Africa. This strategy seeks to avoid risks of total crop failure rather than maximizing yields of one particular crop. Also in Ethiopia, crop diversification is widespread. Crop diversification is the most commonly used method to overcome the impact of climate change and variability in Ethiopia. Diversification is identified as a coping strategy that has evolved to deal with both expected rainfall uncertainty and seasonal fluctuations in rainfall (Cooper, 2008).There are many benefits with crop diversification. It is more secure because if one variety fails, farmers have probably some other crop varieties that are successful. Secondly, with rotating of crop varieties on each plot of land, soil fertility will be maintained and the soil will not be exhausted (Belay et al., 2017).

**2.6.3.2. Irrigation**

Rain fed agriculture in sub Saharan Africa will remain vital for food security (Cooper, 2008). At the same time, irrigation can be a valuable strategy for making agriculture more stable and safe. Types of irrigation are for example dams and ponds, hand dug wells and other types of wells, flood irrigation, sprinkler irrigation, lifting water using a petrol-fuelled pump engine, and irrigation by gravity. Use of irrigation is one of the least practiced adaptation strategies among the major adaptation methods identified in Ethiopia (Kide, 2014).

**2.5. Climate change perception**

The linkage between agriculture and climate is much more complex than others, and farmers are able to identify specific and important weather patterns. Farmers usually base their crop and other production decisions using local knowledge systems which are developed from years of observations and experiences. Farmers‟ perception to climate change in Sekyedumase district in Ghana showed that about 92% of the respondents perceived increases in temperature, while 87% perceived decrease in rainfall over the years. Even though the communities are highly aware of climate issues, only 44.4% of farmers have adjusted their farming practices to reduce the impacts of increasing temperature and 40.6% to decreasing rainfall, and mentioned that lack of funds as the main barrier to implementing adaptation measure (Fosu-Mensah et al., 2012).

Bryan et al. (2009) on adaptation to climate change in Ethiopia and South Africa which examined farmers‟ perceptions of climate change in Ethiopia and South Africa. The result showed that even though farmers perceived changes in temperature and rainfall, a large percentage of farmers did not make any adjustments to their farming practices. Belaineh et al. (2013) also found that there are nearly unified perceptions of climate variability and change among gender and social groups. Abid et al. (2015) studied farmers‟ perceptions of and adaptation strategies to climate change and their determinants in Punjab province of Pakistan. The results demonstrated that awareness of climate change is widespread throughout the area, and farm households make adjustments to adapt their agriculture in response to climatic change.

For poor farmers, adaptation strategies to climate change are vital because failure to take adaptation measures could lead to social problems and displacement. Nega et al. (2015) suggested that most participants perceived climatic change and its negative impact on agriculture and considered climate change as a salient risk to their future livelihoods and economic development. Different levels of perception were expressed in terms of climate 20 change and the impact on traditional rain-fed agriculture. Age, education level, livestock holding, access to climate information and extension services significantly affected perception levels.

The farmers‟ perceptions to climate change found to be statistically and significantly related to factors such as marital status, farm size, climate change information access and the level of income generations (Solomon et al., 2016). In Maritime, Plateau and Savannah Regions of Togo, the analysis of farmers‟ perception to climate change revealed high increase in temperature and decrease in rainfall. These results were in accordance with the trend analysis of climate data records in the study area particularly on the temperature (Gadédjisso-Tossou, 2015).

Smallholder farmers‟ perceptions and adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia using a descriptive statistics and MNL model. The result showed that 90% of farmers have already perceived climate change and 85% made attempted to adapt (Abrham et al., 2017). Climate change perception and choice of adaptation strategies base on empirical evidence from smallholder farmers in east Ethiopia. Majority of farmers in the study area are aware of climate change patterns and their adverse effect on income, food security, diversity, forest resources, food prices and crop and livestock diseases (Wondimagegn and Lemma 2016).

**2.6. Empirical Review**

Several factors affect the decision of the household to choose among adaptation strategy employed to climate change in agriculture. Different studies are conducted on the determinants of adaptation strategies choice to climate variability in many part of the world including Ethiopia, using multinomial logit model. The studies documented below present empirical findings on adaptations to climate change. The results indicated that using different crop varieties, crop diversification, changing planting dates, 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 long-term increase in temperature and that the region was getting drier, with changes in the timing of rains and frequency of droughts (ATA, 2014 and Yayeh, 2017).

Kide (2014) studied that the climate changes perception and adaptive response of smallholder farmers in central highland of Ethiopia. The study was assessed smallholder farmers‟ perception of climate change; its impact on agricultural production and their adaptive responses. The result of the study shows that farmers‟ perceive change in climate (increase in temperature and decrease in rainfall). Decline in length of growing period; increase crop damage by insects and pests; and increase severity of weed infestation are the reported impacts due to change in climate.

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

Similarly, the finding of legesse et al. (2012) studies on smallholder farmers’ perceptions and adaptation to climate variability and climate change in Doba district, western Harerghe, Ethiopia. They are investigated the determinant factors influencing adaptation strategies to climate variability and change. The adaptation strategies were crop diversification and the use of soil and water conservation practices, integrated crop and livestock diversification, engaging in off-farm income activities and rain water harvesting. The result of the MNL model revealed that agro-ecological location, sex, family size, plot size, off-farm income, livestock holding, frequency of extension contact and training are the determinant of factors influencing adaptation strategies.

### 2.7. Conceptual framework

Currently climate variability is a serious global issue; it is manifested through different process, such as increase in temperature, rise in sea level, variability on rain fall etc. and it has adverse effect on human being directly or indirectly. In order to minimize the adverse effect of climate variability taking adaptation measure is an important option. Nevertheless, in order to take different adaptation measures, first farmers have to perceive the change on local climate and identifying the factors that hinder and facilitate adaptation practices is crucial because, they have influence on the implementation of adaptation measures to climate change impact (Yayeh, 2017).

There is a need to examine the interrelationship and interactions of various factors revolving around the adaptation strategy choice of smallholder farmers. Therefore, the lives and livelihoods of the rural community and thereby their adaptation strategy choice decisions are affected by such stresses and their associated consequences. Adaptation to climate variability and risks takes place in a dynamic social, economic, technological, biophysical, and political context that varies over time, location, and sector. Understanding the diverse and dynamic of any rural adaptation strategies helps to identify appropriate strategies for intervention to introduce new strategies that have greater impact on the reduction of climate change adverse effect on smallholder farm. Some of the main features of communities or regions that seem to determine their adaptive capacity and thereby their adaptation strategies are economic wealth, technology, information and skills, infrastructure, institutions, and equity (Buchhorn et al., 2020).

**Socio-Economic factors**

- Income
- Land ownership
- Crop production
- Livestock ownership

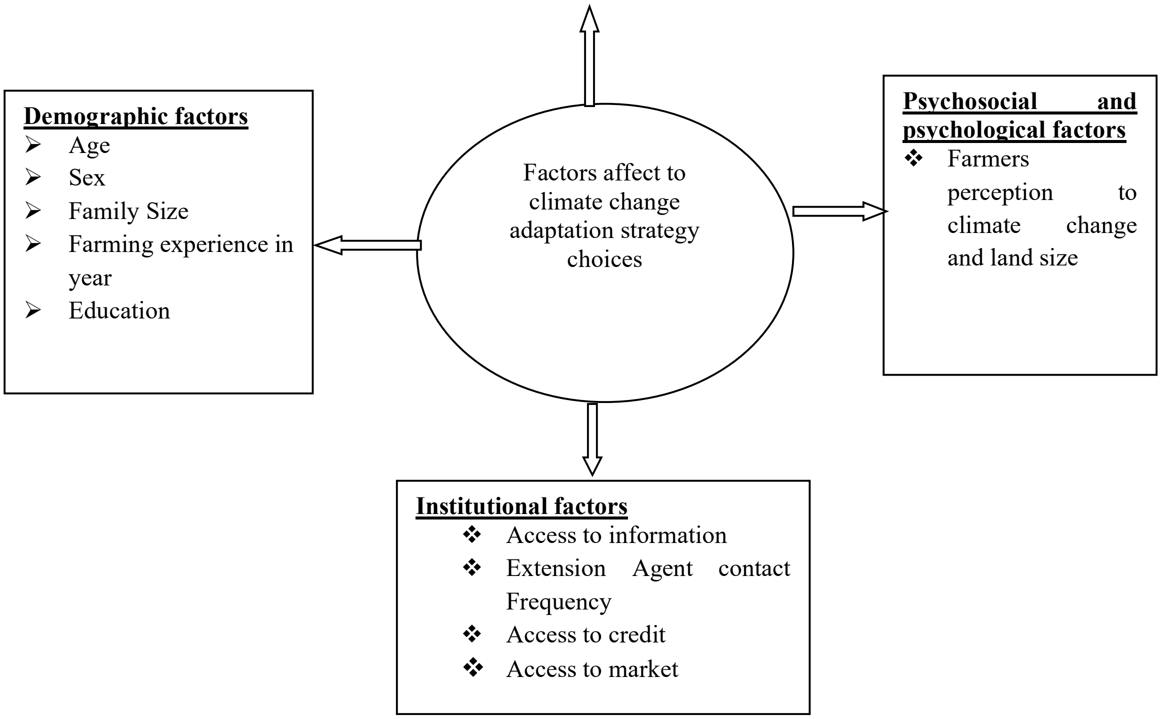


Figure 1.Conceptual framework on adaptation strategies to climate change (Source: from ATA, 2017: ATA 2014: William, 2013)

## 3. RESEARCH METHODOLOGY

### 3.1. Study Area description

#### 3.1.1 Study Area Location

The study was conducted in Abala Abaya Woreda which is one of the twenty two Woreda's of Wolaita zone, Sothern Ethiopia. It is located on the North by Hobicha Woreda, on the East by Sidama, on the South East by Abaya Lake on the West by Humbo Woreda and by South Mirab Abaya. It is found at 107 kilometers far apart from Arbaminch, 28 km from Wolaita Sodo, 191 kilometers from Hawassa and 391 kilometers from Addis Ababa.

 

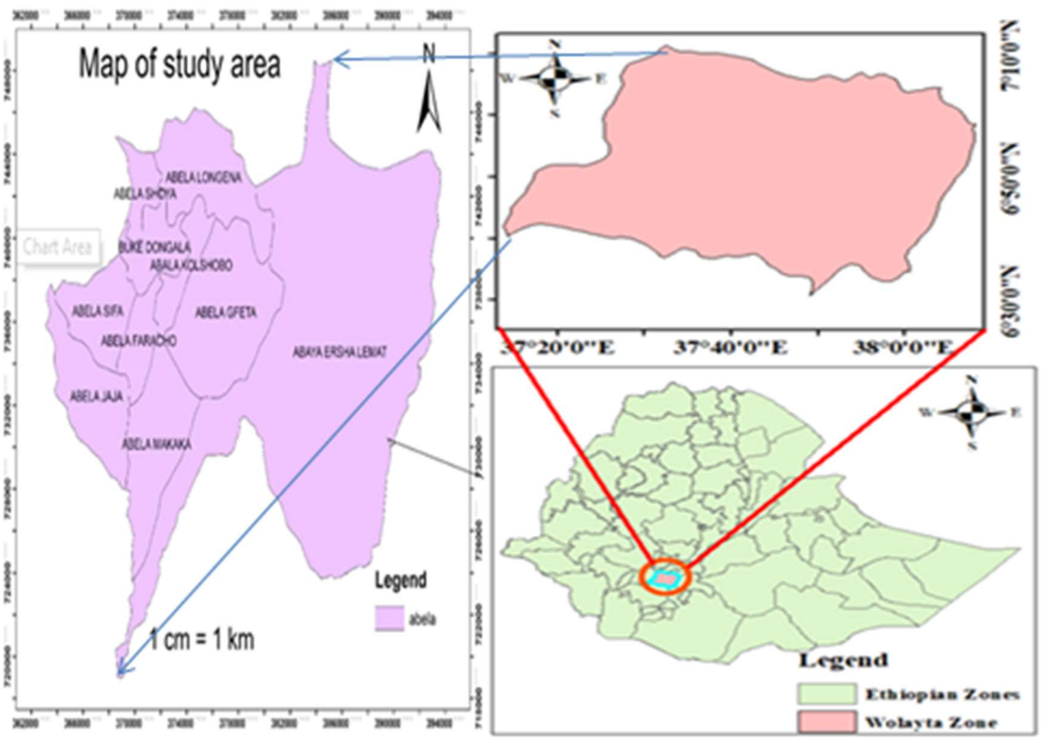


Figure 2 Administrative Map of Abala Abaya Woreda

**3.1.2. Population**

Demographically 94.98% of the total population understudy resides in rural area while about 5.12 % of the total population of the Woreda lives in urban area. Moreover, the age of population between 15 and 64 years are considered to economically active population, it constitutes for about 56.7 % of the total population. On the other hand, the inactive age or economically dependent age group (less than 15 and above 64 years age) forms 43.3 %.The sex ratio of the Woreda is 1:1.01 meaning that 1 males per females, indicating approximately equal number of males and females in the district(AAWFEDO, 2020).

**3.1.3. Climate**

Abala Abaya characterized by agro-ecological zones kola (lowland). The estimated mean annual total rainfall is about 2280 mm and it has two rainy seasons, the rainfall in. The annual average temperature is 21.86°C (AAWFEDO, 2020**)**

**3.1.4. Soil Type**

In Abala Abaya District, soil type is characterized by proportionally black clay loam (AAWFEDO, 2020)

**3.1.5. Livelihood**

Agriculture serves as the main economic foot means of livelihood and it is characterized by traditional mixed farming which includes both crop, and livestock production. Crop production is the basic economic activity in the study area. Additionally the district has many used traditional type of irrigation (AAWFEDO, 2020).

**3.1.6. Crop**

The major crops grown in the area include maize, sweet potato, "teff," coffee, "Enset", taro, haricot bean, chick pea, pea, wheat, barley, etc. Crops such as maize, "teff", sweet potato and Enset are the major cereals and root crops grown and they occupy the largest proportion of cultivated land. Fruits, 'masho', "teff" and potato are grown mainly as cash crops. Enset and maize are staple foods in the study area .Livestock production is one of the important activities in the study area. Farmers in the study area keep animals such as cattle (oxen, cow, heifers, and bulls), small ruminants (goat and sheep), donkey, horse, and chicken. It contributes to the subsistence requirement of the population in terms of milk, milk products and meat. Livestock plays great role in income generating activities (AAWFEDO, 2020).

**3.1.7. Social Infrastructures**

Abala Abaya District has some social infrastructures like stone, road, schools, religion institutions, agricultural extension service centers, and health centers (AAWFEDO, 2020).

**3.2. Methods**

The data set which was used to achieve the objectives of this study was collected from AAWIO.

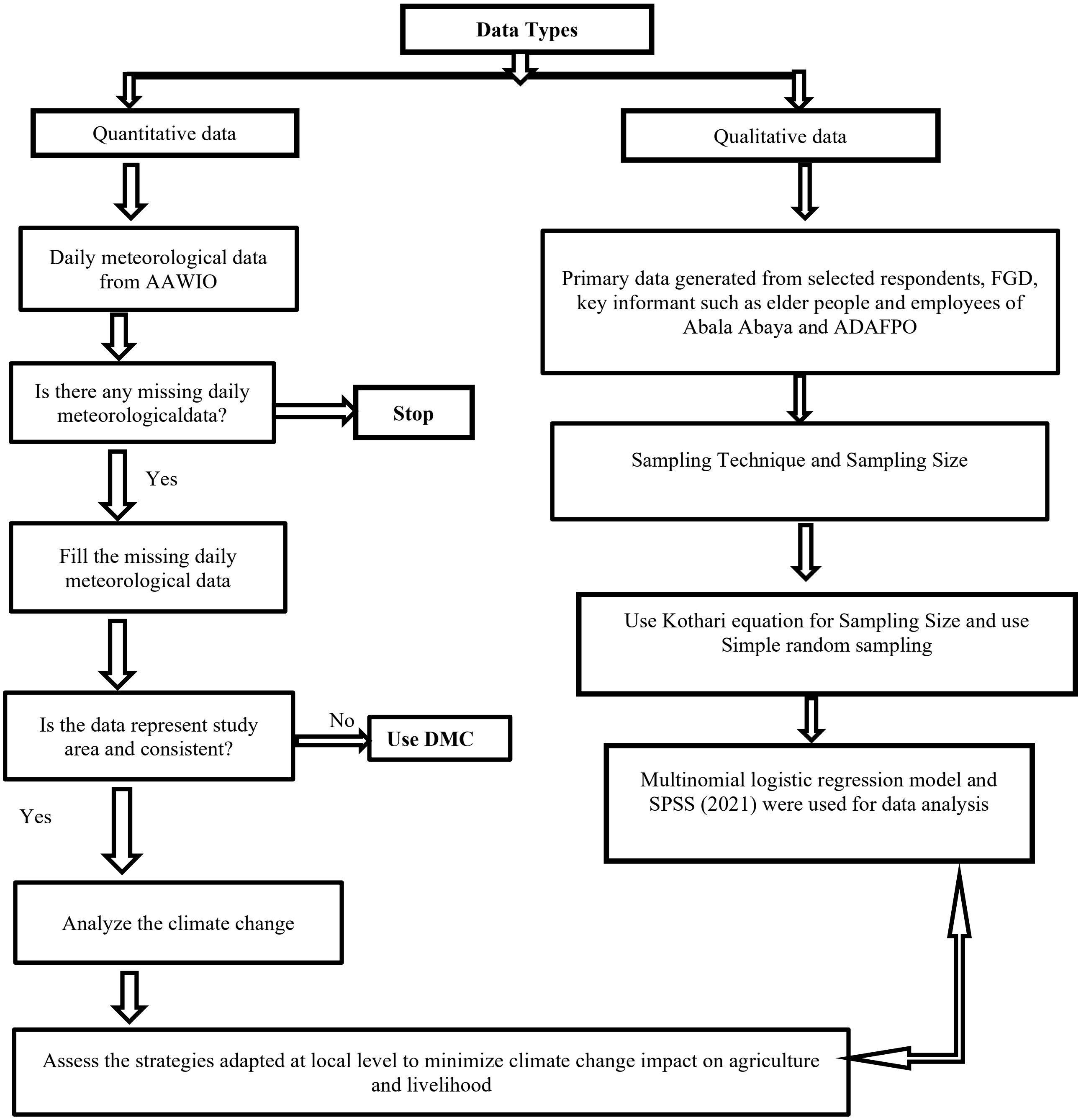


Figure 3. The general flow chart of the study

**3.2.1. Missing data estimation**

Meteorological data are an important climatic parameter and the study on this parameter is commonly hampered due to lack of continuous data. To estimate the missing observations in data, a few selected methods including Arithmetic Mean method, Normal Ratio method and Inverse Distance method (Ratnasiri et al., 2007) were used for the estimation of missing rainfall data.

- **Arithmetic Mean method**: Chow *et al.*, (1988) said it is often necessary to estimate this missing record and to fill the data the commonly used data estimating methods are the arithmetic mean. And the normal meteorological data at station, X, is calculated as:

$$M_x = \frac{1}{N}\sum_{i=1}^{n} Ri \qquad (1)$$

Where - Rx is missing meteorological data for any storm at station, Ri is meteorological data at the i[th] station and n is number of nearby stations

### 3.2.2. Data consistency

The recorded data may be occurred due to change in location of the rainfall station, instruments, observing practices and station environments (Peterson et al., 1998). To test the consistency of rainfall data recorded by all the stations, double mass curve was applied. To test the consistency of station, the annual values as well as their cumulative were obtained and checked by adding trend lines in the obtained linear equations.

The station data which is not consistent is adjusted by the following equation.

$$S_{cx} = \frac{m_{bd} * S_x}{m_{ad}} \qquad equation\ (2)$$

Where $s_x$ is Station data for any storm at station ,$S_{cx}$ is corrected station data for any storm at station, $m_{bd}$ is slope of data before departing from the trend an and $m_{ad}$ is slope of data after departing from the trend

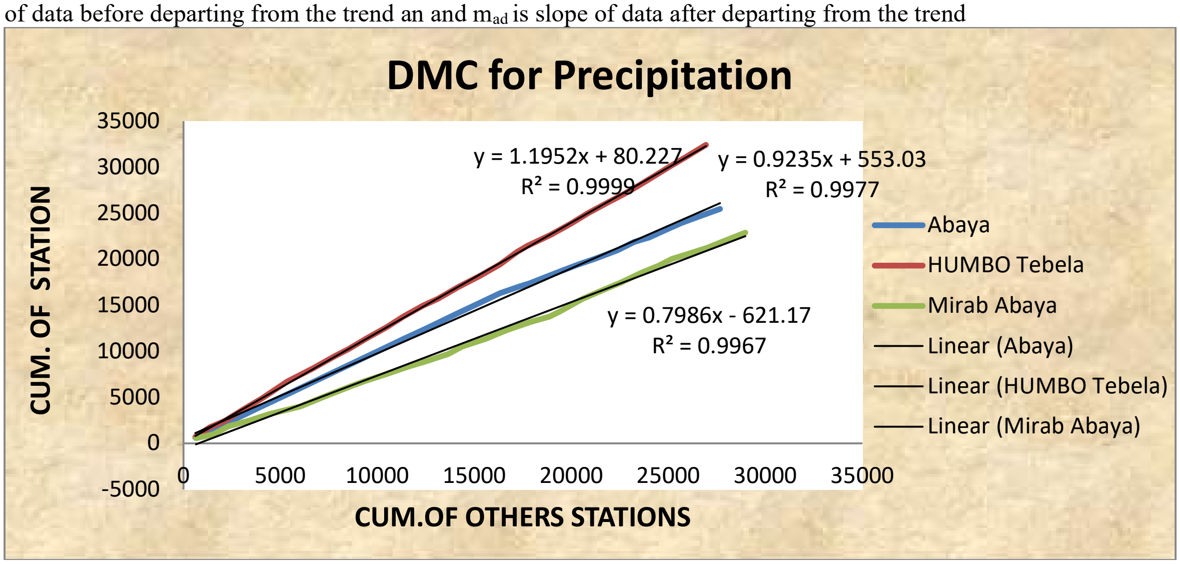


Figure 4.DMC of the metrological stations

### 3.3. Sampling Techniques and Sample Size

Abala Abaya is selected due to high exposure to droughts, weak adaptive capacity, high level of food insecurity problems, high potential for crop production and etc. For this study, simple random sampling techniques were employed to select the sample of respondent households. First, among rural kebeles, four rural kebeles were selected, using simple random sampling technique. Out of total population (2166), 94 respondents were included in this study. Then using probability proportion to sample size techniques household heads was randomly selected. Finally, the sample size of the respondents was determined by using Kothari (2004) sampling design formula:

$$n = \frac{Z^2 PqN}{e^{2(N-1)+Z^2}\ Pq} = 94 \qquad \text{equation (3)}$$

Where n=sample size; N=total population (2166); Z=95%confidenceinterval under normal curve (1.96); e=acceptable error term (0.05) and P and q are estimates of the proportion of population to be sampled (P=0.5 and p + q= 1). 7% of error term (e=0.07) was used to take representative and cost-effective data for this study.

Table 3.Sample size by kebele

| S.No | Kebele | Total HHs | Sample HH |
|---|---|---|---|
| 1 | Abela Sifa | 636 | 29 |
| 2 | Abela Kolishobo | 582 | 27 |
| 3 | Abela Jaja | 482 | 20 |
| 4 | Abela Faracho | 466 | 18 |
| **Total** | | **2166** | **94** |

Source: Own estimation result, 2021

### 3.4. Sources and Methods of data collection

Both primary and secondary data were used for the study. The primary data was collected from households directly through interview. The questionnaire was developed and pre-tested to evaluate for consistency, clarity and to avoid duplication and to estimate the time requirement during data collection. Appropriate training, including field practice, was given to the enumerators to develop their understanding regarding the objectives of the study, the content of the questionnaire, how to approach the respondents and conduct the interview.

This study employed both qualitative and quantitative data collection methods. The qualitative data at community level were collected through focus group discussions, key informant interviews, and observations. Four focus group discussions (FGD) involving 12-16 participants selected purposively in each group. The FGD for this study were held with groups of elders, youth and women including model farmers, development agents, and district officials in each Kebele.

Key informant interviews were held with knowledgeable people from the community, including the agricultural staff, administrators from government offices, and NGOs. These were individuals who have access to information on weather forecasts, climate change impact, and constraints to adapting to climate change. In addition, data at the household level were collected through a household survey using structured questionnaires. The local language, Wolaitegna, was used for effective communication for the household survey, focus group discussions and key informant interviews. Research assistants fluent in Wolaitegna and with good knowledge of local traditions were recruited and trained before conducting the survey.

### 3.5. Methods of Data Analysis

In this study, descriptive method and econometric data analysis were used to analyze the data.

#### 3.5.1. Descriptive statistics

Descriptive statistics was used to describe the basic features of the data in the study. In this study, demographic, institutional factors, psychosocial factors and socioeconomic data were summarized and presented using descriptive statistics such as frequency, percentage, graphs, figures, and tables. Also t test and Chi-square tests were used in order to compare the difference among groups for different socioeconomic institutional factors, psychosocial factors and demographic variables. This test is mainly employed to know whether the difference is statistically significant or not. For this analysis, both Microsoft Excel and SPSS 2021 were used.

#### 3.5.2. Econometric data analysis

In this study, the determinants of farmers' adaptation decisions to climate change were analyzed using MNL. The method was used to analyze the choices that the farmers make regarding crop- and livestock-based adaptation strategies and what factors determine those choices. The MNL model was used based on the previous literature on determinants of farmers' adaptation to climate change. This model suits such type of analysis as it permits the analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories. However, the model requires that households are associated with only their most preferred option from a given set of adaptation strategies.

The model is specified as follows. Let Y denote a random variable with values {1,2…J} for a positive integer J and X set of variables. In this study, Y is a dependent variable and represents the adaptation alternatives (strategies) from the set of adaptation measures, whereas the X represents the factors that influence choice of the adaptation strategies which contains household attributes as described in Table 2, and P1, P2…Pn as associated probabilities, such that P1 + P2 + … + Pn = 1. This tells as how a certain change in X affects the response probabilities P(y = n/x), j = 1, 2 …N. Since the probabilities must sum to unity, P(y = j/x) is determined once the probabilities for j = 2,3, 4, 5…N are known.

$$P\left(y = \frac{1}{x}\right) = 1 - (P2 + P3 + P4 + \cdots . + Pn) \qquad \text{equation (4)}$$

In the MNL model, it is usual to designate one as the reference category. The probability of membership in other categories is then compared to the probability of membership in the reference category. Consequently, for a dependent variable with j categories, this requires the calculation of n − 1 equations, one for each category relative to the reference category, to describe the relationship between the dependent variable and the independent variables. The choice of the reference category is arbitrary but should be theoretically motivated. The estimation of MNL model for this study was conducted by normalizing one category which is named as "base category" or "reference estate." The adaptation measures were grouped into eight because farmers used more than one strategy, and the base category was "No adaptation strategy." The theoretical explanation of the model is that in all cases, the estimated coefficient should be compared with the base group or reference category. Therefore, the choice of the reference category is based on empirical literature and theoretically motivated. The generalized form of probabilities for an outcome variable with j categories is:

$$P\left(yi = \frac{n}{x}\right) = Pij = \frac{\exp\,(X'Bn)}{1 + \sum_{n=2}^{n} \exp\,(X'Bn)} \qquad , n = 1,2,3 \ldots . . J \qquad \text{equation (5)}$$

Differentiating the above equation with respect to the explanatory variable provides the marginal effect of the independent variables which give as

$$\frac{dpi}{dxk} = pn\left(Bnk - \sum_{n=1}^{n=1} PnBnk\right) \qquad \text{equation (6)}$$

Marginal effect of marginal probabilities is the function of probabilities and measures the expected change in probabilities where particular adaptation choice is being made by a unit change of the independent variable from the mean.

### 3.6. Definition of Variables and Working Hypothesis

#### 3.6.1. Dependent Variables

Dependent variables for multinomial logistic model used in this study are smallholder farmers' choice and actual adaptation strategies. The most common adaptation methods cited in the literatures include; different crop varieties, mixed crop and livestock farming, increased use of water and soil conservation techniques, tree planting, changing planting date, diversifying from farm to nonfarm activity and irrigation (Deressa,2011).

- **Soil and water Conservation**: households have been practiced it includes different structure of soil conservation such as soil bund, stone bund, deep trench, terraces, half moon, area closure and plant trees Regarding to water conservation, it consists of geo-membrane, man-made pond, irrigation, ground water harvesting, etc. (Abid et al., 2015).
- **Crop variety and livestock**: is used to mix crop varieties and livestock as strategy options. Households have been used crops such as short duration crops and planting trees while livestock production are used income generation to response to adverse effect of climate change (Hirpha, 2020).
- **Crop diversification:** Farmers produced various kinds of crop varieties within farmland to adapt climate change hazards such as planting tree, drought tolerant crops and short duration crops which prevent general crop failure when climate change is occurred (Legesse et al., 2013).
- **Combined adaptation strategies:** Farmers are used different adaptation strategies in combination as adaptation option such as income diversification, irrigation with improved seeds and agronomy practices (Hirpha, 2020).
- **No adaptation:** Is the other option that smallholder farmers may not response (not use any adaptation method) to climate change (Buchhorn et al., 2020).

#### 3.6.2. Independent variables

The independent variables are the factors that affect choice of adaptation methods to climate variability. Therefore, in this study, sex, age, education, family-size, farmland size, total farm income, total income, non-farm income, livestock ownership, farming experiences, use credit, distance to market, and access to climate change information and farmers' perception to climate change were independent variables.

- **Sex of head household:** It is dummy variable taking value 1, if the household head is male and 0, otherwise. Tessema et al. (2013) and Legesse et al. (2013) stated that male-headed households were likely to perceive varies in climate than the female counterpart. Therefore, it is hypothesized that male-headed households are more likely to take climate variability adaptation.
- **Age of the household head:** It is continuous variable and expressed in years. Age matters in any occupation, rural households mostly devote their life time or base their livelihoods on agriculture, and it is believed that the older the household head, the more experience he has in farming and weather forecasting. Tessema et al. (2013) indicate that experience in farming increases the probability of uptake of adaptation measures to climate variability. Similarly, this study hypothesized that experience increases the probability of adapting to climate variability.
- **Education level of head household**: Educational level of head household is continuous variable taking value of years of schooling. Legesse et al. (2013) study reveals that highly educated persons were likely to perceive that climate is varying than uneducated ones. Therefore, this study also hypothesized that farmers with higher level of education are more likely to opt for implementing adaptation measure to climate variability.
- **Family size:** it is referred to the total number of the family consisting of husband, wife, children and other dependents. Tessema et al. (2013) studied that large family sizes are more likely to have a significant effect on change adaptation strategies to climate variability. Therefore, this study hypothesized that, the families with the larger size, are the likely to opt for implementing adaptation measure to climate change variability.
- **Farming Experience:** it is continuous variable and measured farming experience in year. Tessema et al. (2013) and Legesse et al. (2013) study reveals that the farmer's best placed to pronounce on whether climate variability has occurred are presumably those who have had the most experience of farming experience were more likely to notice varies in climatic conditions. Therefore, this study hypothesized that farming experiences positively affect to take up an adaptation strategy
- **Income from non-farm activities:** It is continuous variable and measured in Eth. birr. It refers to total annual income obtained from non-farm activities. Income diversification has a great contribution to improve the livelihood of rural household by reducing pressure from agriculture and increasing the household coping

natural shocks (Deressa et al., 2008).

- **Landholding size:** It refers to the size of land owned by the household and continuous variable measured in hectare. Land is the basic asset of the majority of rural household. Legesse et al. (2013) indicated that farm size increases the perception and adaptation to climate variability strategies as farmers with large land can avoid making some capital-intensive adaptation like irrigation. It is hypothesized that the larger the farmer's landholding size, the more likely increase the probability of adapting to climatic variability.
- **Livestock ownership:** Livestock owned by household is continuous variable measured in tropical livestock unit (TLU). Livestock plays a very important role by serving as a store of value, source of traction (especially oxen) and provision of manure required for soil fertility maintenance (Tessema et al., 2013). For this study, better livestock ownership hypothesized to increase adaptation to climate variability.
- **Frequency of extension contact**: It is the number of development agent contact with the farmers per year. Agricultural extension enhances the efficiency of making adoption decisions and in the specific case of climate variability adaptation. Abraham (2016) indicated that access to extension service increases the probability of perceiving the climate change and increase the likelihood of uptake of adaptation techniques. Thus, this study hypothesized that access to frequency of extension agent contact increases chance of adapting to climate variability
- **Access to information of climate variability:** It is a dummy variable that takes 1, if households have an access to climate change information and 0, otherwise. Access to climate variability information increases the perception of climate change at households and hence increase the probability of farmers to take adaptation measure (Abraham, 2016 and Belay et al., 2017) .Therefore, this study hypothesized that access to climate variability information positively affect the decision of farmers to take up climate adaptation measures.
- **Market Distance:** Access to market continuous variable measured in kilometers from homes. Proximity to market is an important determinant of adaptation, presumably, because the market serves as a means of exchanging information with other farmers (Belay et al., 2017). Therefore, this study expected that households nearer to the market take more climate adaptation measures and otherwise negatively related.
- **Farmer's perception towards climate variability:** It is dummy variable and it will take the value 1, if farmers perceive climate variability and 0, otherwise. Belay et al., in 2017 said that noticing climate change increases the probability of uptake of adaptation measures. Thus, this study hypothesize that farmers who are aware of climate change tend to take measure against climate variability.

The choice of independent variables was dictated by empirical literature, behavioral hypotheses suggested by it, and data availability. Hypotheses have been developed around explanatory variables concerning their expected influence on farm level adaptations.

Table 4. Explanatory variables

| **Independent variables and its value** | **Description** | **Ex/sign** |
|---|---|---|
| Sex of household head ( if M=1, F=0) | Dummy | +ve |
| Age of the household head in year | Continuous | +ve |
| Education level of the HHs in year of attained formal education | Continuous | +ve |
| Farm experience of farmers in a year | Continuous | +ve |
| Family size of HH in adult equivalent unit(AE) | Continuous | +v |
| Total annual income from farm | Continuous | +ve |
| Land owned by household in hectare | Continuous | +ve |
| Livestock holding by tropical livestock unit TLU | Continuous | +ve |
| Number of visit by Ex. Agent in a year | Continuous | +ve |
| HHs utilization of credit service(if Yes=1 other wise=0) | Dummy | +ve |
| Distance to market in kilometer | Continuous | -ve |
| Access to climate variable information(0= No, 1=Yes) | Dummy | +ve |
| Farmers variable(1=Yes,0=No ) | Dummy | +ve |

## 4. RESULTS AND DISCUSSION

This part of the study deals with the analysis and interpretation of the data obtained from the questionnaire. After the data collection was completed the data obtained by using questionnaires, and different document is presented and analyzed as follows.

### 4.1. All characteristics of respondents

In this study, 91.5% HHs were male-headed HHs and the remaining 8.5% were female-headed HHs. The result is almost agreed with the national coverage as reported by CSA (2012). They indicated that small amount of the HHs in rural areas of the country are headed by women. Furthermore, details regarding the age and family size of respondents showed that the youngest HH head was aged 22-30 years whilst the oldest was aged 51-70 years. Aged farmers can perceive the local climate condition and have higher probability to adapt the changing climate than younger farmers. The family size of HHs ranges from 1 to 15 members, with mean of six persons per HH which agrees with the reports of CSA (2012) that revealed that on an average, HH in rural area of the country had about five individuals.

The study showed that the educational status of smallholder farmers ranges from 1 to Diploma. About 81.9% of the respondents attended formal education from 1-12 and the remaining 18.1% of respondents attend Diploma. Education level of HHs has substantial impact on the adoption of adaptation strategies to climate change. Belay et al. (2017) designated that educational level of HHs need to be enhanced as it plays an important contribution to adopting adaptation measures and enhance agricultural production.

The study indicated that about 47.9% of HHs have access to information from Farming experience, 12.8% of HHs have access to information from other farmers and 39.4% of HHs have access to information from extension agent. This showed that most of the HHs has averagely less information, appropriate advice and technical support from development agents (DAs) on agricultural activities which could enhance their ability to adapt to climate-related shocks.

This result should be improved by the stakeholders according to the reports by Birtukan and Abraham (2016) and Belay et al. (2017) who stated that HHs' access to extension contact is likely to enhance their adoption of climate change adaptation strategies. Crop production in the study area is both by using rain and irrigation as indicated in table 1 below. Majority of the HHs (63.8%) had access to credit service from farming input. This relaxes the financial constraints of farmers to adopt technology and enhance their climate resilience.

Most of the farmers had access to climate information given from the extension Agent contact Frequency. The study indicated that about 56.4% of HHs have access to contact twice with the extension Agent contact Frequency. This suggests that the greater part of the rural farmers in the study area do not utilize the climate information given by the stations, which negatively influences them to do adaptation practices to climate change. Deressa et al. (2008) stated that farmers' access to market can enhance and diversify the practices of adaptation strategies to climate change. The results further revealed that 81.9% had no access to market service, whereas 18.1% had access.

Table 5. Characteristics of respondents

| Characteristics | Description | Frequency | % |
|---|---|---|---|
| Age | 20-30 | 20 | 21.3% |
| | 31-40 | 31 | 33.0% |
| | 41-50 | 30 | 31.9% |
| | 51-70 | 13 | 13.8% |
| sex | Female | 8 | 8.5% |
| | male | 86 | 91.5% |
| Family Size | 1 | 2 | 2.1% |
| | 3-5 | 36 | 38.3% |
| | 6-8 | 41 | 43.6% |
| | 9-15 | 15 | 16.0% |
| Farming experience in year | 0nce | 23 | 24.5% |
| | Twice | 52 | 55.3% |
| | Three times | 19 | 20.2% |
| Education | 1-12 | 77 | 81.9% |
| | Diploma | 17 | 18.1% |
| Income | Farm income | 90 | 95.7% |
| | Both | 4 | 4.3% |
| Crop production | By rain | 28 | 29.8% |
| | Both | 66 | 70.2% |
| Livestock ownership | Owner | 62 | 66.0% |
| | loan | 10 | 10.6% |
| | Government | 22 | 23.4% |
| Access to information | Farming experience | 45 | 47.9% |
| | from other farmers | 12 | 12.8% |
| | extension agent | 37 | 39.4% |
| Extension Agent contact Frequency | once a month | 41 | 43.6% |

| Characteristics | Description | Frequency | % |
|---|---|---|---|
| | two month | 53 | 56.4% |
| Access to credit | Farming input | 60 | 63.8% |
| | Meet basic needs | 34 | 36.2% |
| Access to market | Rare | 77 | 81.9% |
| | Available | 17 | 18.1% |

**4.2. Farmers perception to Climate change**

**I. Maximum and minimum Temperature**

For the observed metrological data seasonal maximum temperature change was analyzed as shown in figure 5, 7 and table 6 below. Seasonal maximum temperature change show higher increases in all seasons especially in spring (Tsiday) (March–May) and summer (Kiremt) (June-August). The overall results of the Seasonal maximum temperature increment ranges from 1.37°c to 5.36°c. The seasonal changes of the minimum temperature show higher increases in spring (Tsiday) (March–May) and summer (Kiremt) (June-August). The overall results of the Seasonal minimum temperature increment ranges from 0.96°c to 4.07°c. According to climate scientists, our world is highly likely to continue to warm over this century and beyond. Results from a wide range of climate model simulations suggest that our planet's average temperature could be between 1.1 to 5.4°C warmer in 2100 than it is today. The result is agreed with the raised idea above and more attention must be given for minimum and maximum temperatures.

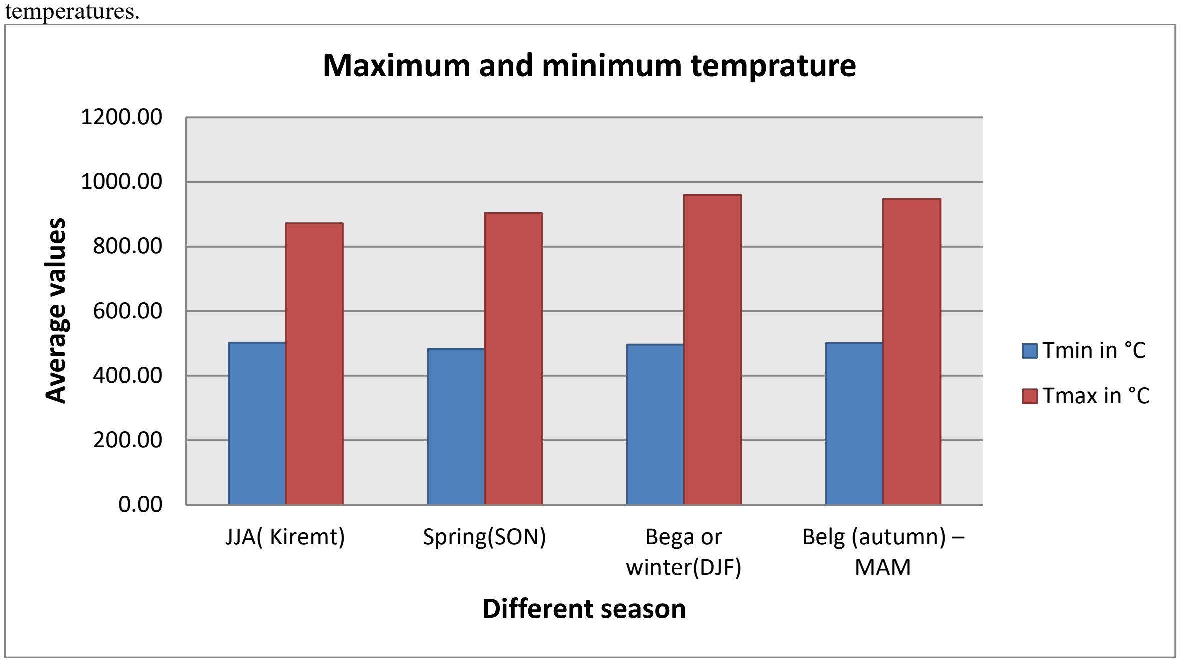


Figure 5. Maximum and minimum temperature

**II. Precipitation**

Figure 6, 7 and table 5 shows the seasonal changes of the precipitation show higher increases in spring (Tsiday) (March–May). The overall results of the Seasonal precipitation increment ranges from 0.1mm to 10.06mm.Figure 6 and table 6 shows precipitation change generally increase from May to September and decrease from December to February. Rainfall seasonality and timing are key climatic features affecting crop yield in rain fed agriculture. A Higher precipitation change is observed in September and large precipitation change reduction is observed in April.

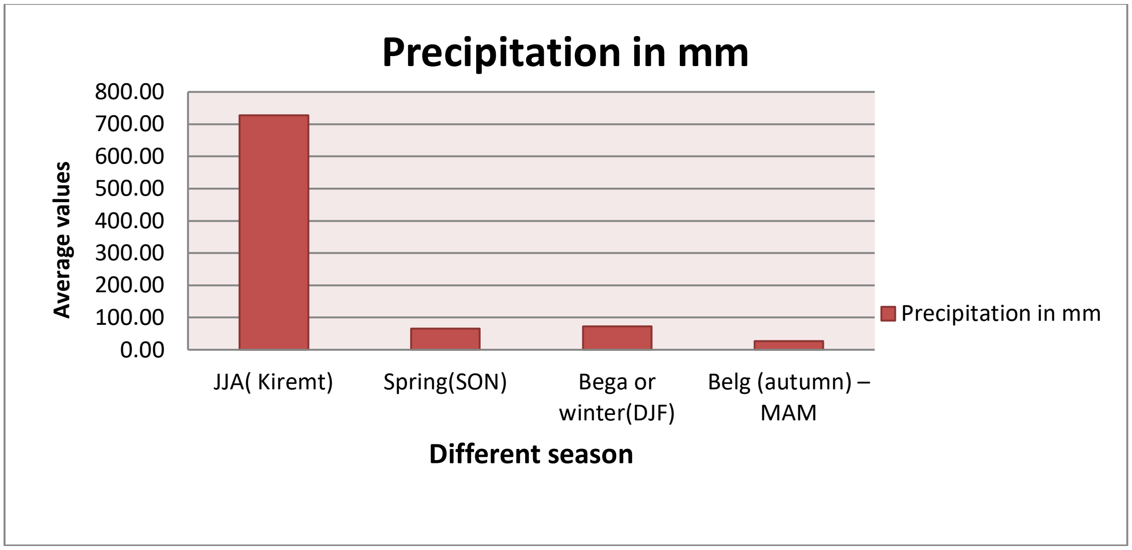


Figure 6.Seasonal change in precipitation

Table 6.Seasonal change in precipitation, maximum and minimum temperature

| Season | Tmin in °C | Change | Tmax in °C | Change | Precipitation in mm | Change |
|---|---|---|---|---|---|---|
| Kiremt | 502.61 | - | 871.10 | - | 727.65 | - |
| Spring | 482.96 | -4.07% | 902.20 | 3.51% | 65.77 | -10.06 % |
| winter | 495.72 | 2.57% | 960.05 | 5.36% | 73.18 | 0.10 % |
| Autumn | 500.46 | 0.95% | 947.06 | -1.37% | 27.22 | -1.69 % |

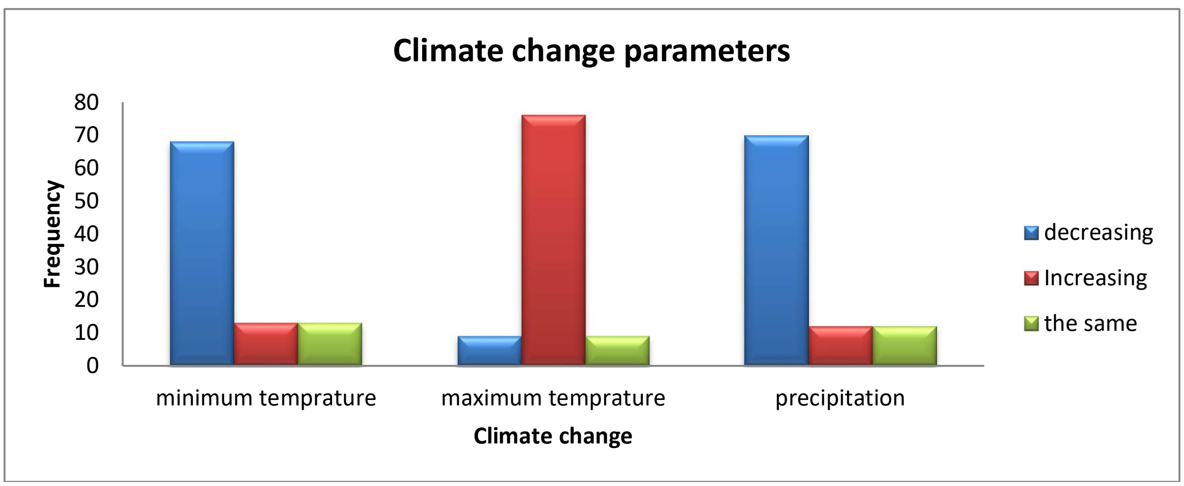


Figure 7. Climate change parameters

**4.3. Impacts of Climate Changes**

This section of the study deals with the analysis and interpretation of impacts of climate changes including flooding, drought, yield reduction, shortage of water and occurrence of pests and disease were presented and analyzed. The main livelihood or income generating activity in the study area following crop production is livestock production. The study indicated that about 12%, 53%, 9%, 13% and 13% of HHs answered the impacts of climate changes are flooding, drought, yield reduction, shortage of water and occurrence of pests and disease respectively as shown in figure 8 below. This result is similar with climate variation can have unconstructive impacts on the productivity of livestock by affecting their health, causing shortage of fodder and grass, reducing water availability particularly during extended drought and deficiency of rain (AAWAO, 2020).

In the study area for the selected Keble, the El-Nino induced drought in 2016/2017 resulted in death of many livestock's. Losses of productivity in crop production impose stern impacts on family food security and lead to malnutrition. During a prolonged dry season and if there is a delay in the onset rain, the land becomes dry and difficult to plough. Particularly, Belg rain delays determine the productivity of the area.

Late onset of rain affects crop productivity by shifting the crop-growing season. In addition to temperature, they describe that rainfall variability also affects the net revenue of rural farmers in Ethiopia.

Temperature and drought increasing, rainfall pattern has changed over time, drought occurs frequently, crop production is decreasing, food insecurity is high in the area, soil moisture is decreasing, domestic animal deaths are increasing, and water resources are decreasing in number due to drying of rivers and springs. Due to seasonal change and prolonged drought season, in the study area they lose indigenous plants such as inset varieties, maize varieties, sweet potato and others". Therefore, the stakeholders have to give a great attention for drought that may lead to yield reduction, shortage of water and occurrence of pests and disease. The societies of the study area as well as stakeholders have to a great attention for the rainy season that may lead to flooding.

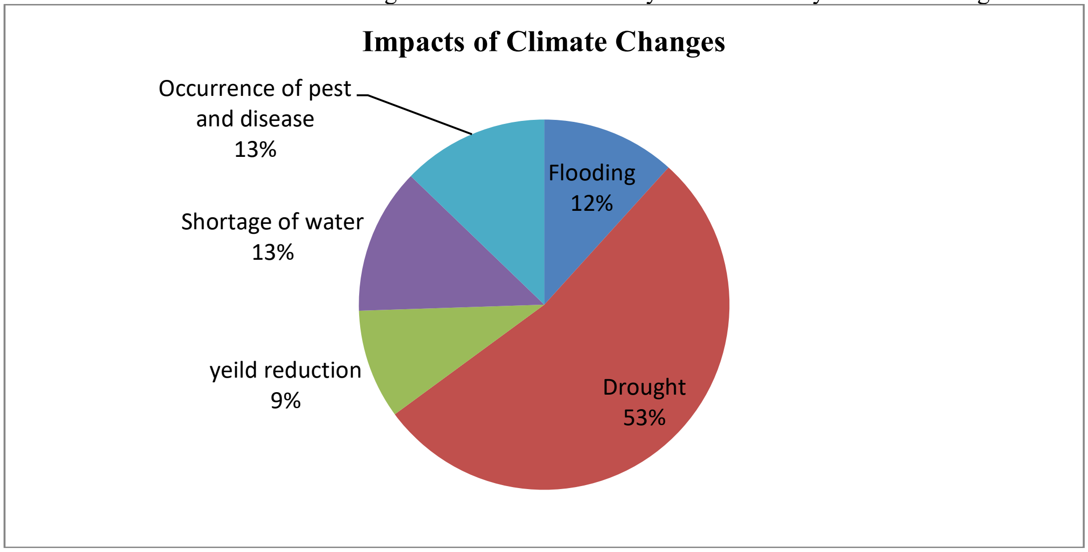


Figure 8. Impacts of Climate Changes

**4.4. Adaptation strategies of the farmers**

The study indicated that about 88% of HHs reported that they have employed various adaptation strategies to adverse effects of climate change and variability. As shown in figure 9a and 9b, 10%, 18%, 23%,31% and 6% of HHs reported that they have employed various adaptation strategies including soil and water conservation, fertilizer application, income diversification, livestock and crop diversification and using irrigation respectively. However, the remaining 12% of the respondents have not done adaptation measures because of different reasons.

This result is similar with Belay et al. (2017) reported in central rift valley region of Ethiopia who indicated that about 88% of the respondents were implementing various types of adaptation strategies to adverse impacts of climate change. The present result is also in agreement with the reports of Tessema et al. (2013) and Legesse et al. (2013) who indicated that the majority of the rural farmers in their study areas have employed different types of adaptation strategies to adverse impacts of climate change. This is obviously in line with the outcome acquired through focus group discussions and key informant interviews. However, the majority of the HHs complained that the ongoing adaptation practices are not adequate to reduce the adverse impact of climate change on their livelihood. This is on the ground that the majority of adaptation measures being carried out by rural farmers are generally represented by simple adaptation strategies.

The adaptation strategies of rural farmers were compared. The results indicated that the types of adaptation strategies employed by farmers were different according to priority of the strategies they used. For instance, the first priority considered by farmers in was livestock and crop diversification (31%) followed by income diversification (23%) and others indicated in figure 9a and 9b below. This result is similar with Hirpha (2020) who indicated that diversifying crops and income diversification were the main adaptation practices employed by rural farmers in Adama district, central rift valley region of Ethiopia.

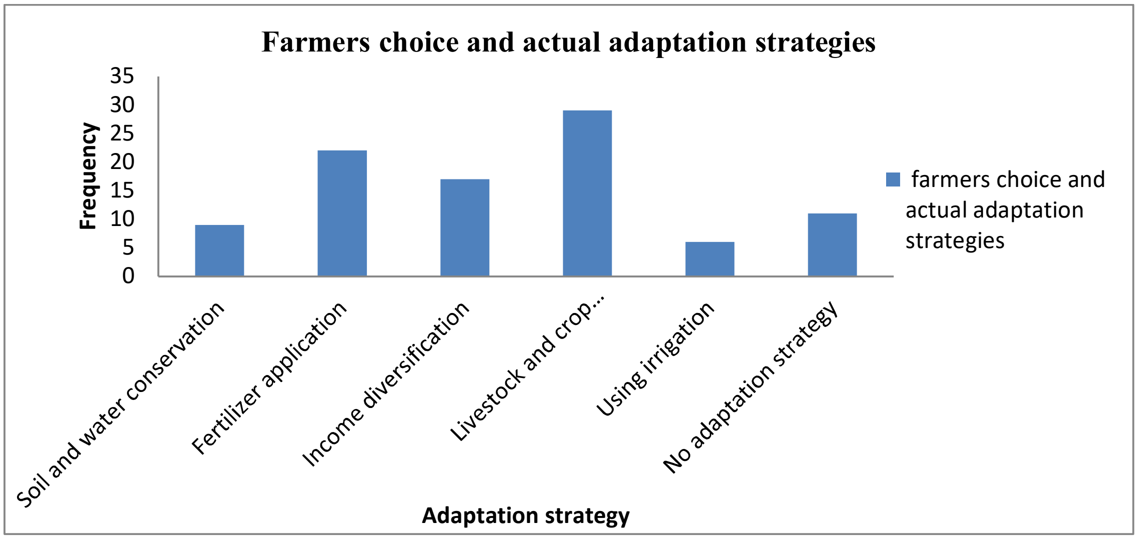


Figure 9a. Farmer's choice and actual adaptation strategies frequency

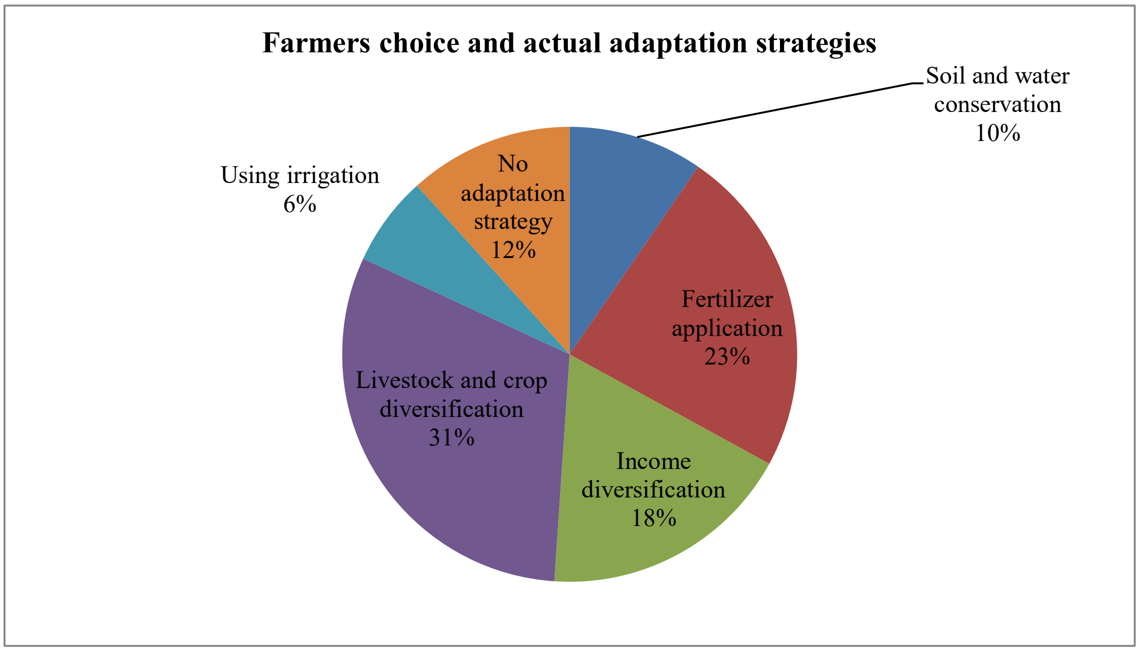


Figure 9b. Farmer's choice and actual adaptation strategies

**4.5. Barricades to adaptation strategies**

In this study, the respondents were asked to answer the barriers to adaptation including lack of finance, shortage of land, lack of information and mass media, lack of skill and education and shortage of labor as shown in Figure 10. The majority of respondents (63%) reported that information and mass media was one of the main barriers to hinder farmer's adoption of climate change adaptation measures. This result is supported by the findings of Abid et al. (2015) and Kide (2014) who showed that lack of climate information, lack of knowledge was the major limitations to hinder rural HHs' willingness to adopt climate change adaptation measures.

About 12%, 10%,9% and 6% of HHs perceived lack of skill and education, shortage of labor, lack of finance and shortage of land respectively as a barrier to climate change adaptation. Land is an important agricultural asset that helps farmers to reduce climate-related risks through crop diversification and use of improved crop varieties. This is in line with the reports of Bryan et al. (2013) and Abid et al. (2015) who revealed that rural farmers with large land size have more capacity to adapt adverse effects of climate change through the use of improved crop varieties. Similar results were reported by Tessema et al. (2013), Belay et al. (2017), Mekonnen (2018) and Nega et al. (2019) who indicated lack of money, lack of information, inadequate labour and shortage of land as major barriers to adaptation measures.

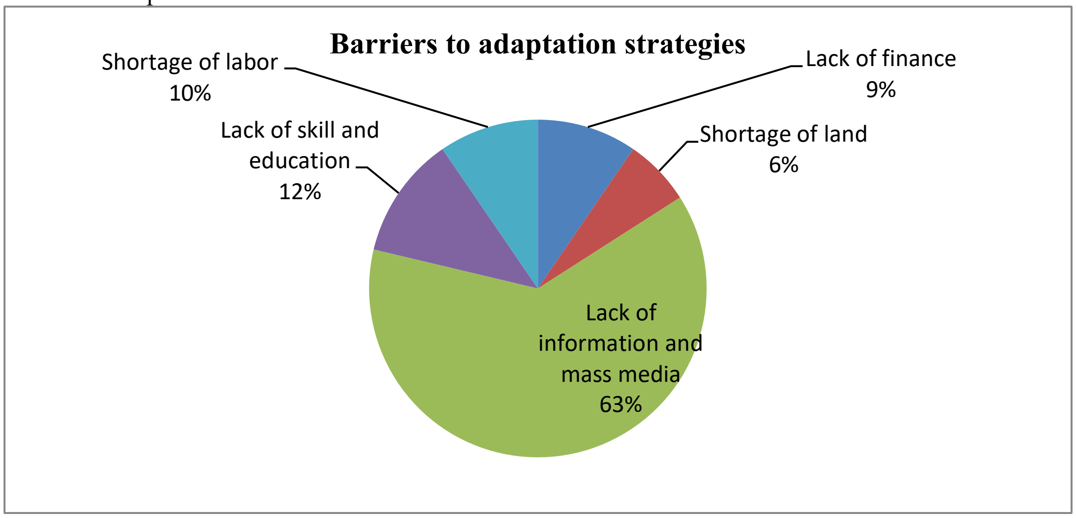


Figure 10. Barriers to adaptation strategies

### 4.6. Determinants of adaptation strategies

In this study, determinants of farmer's choice of adaptation strategies were estimated by using multinomial logistic regression model. The explanatory variables are categorized as soil and water conservation, fertilizer application, income diversification, livestock and crop diversification, using irrigation, crop diversification with improved variety. The results indicated that all explanatory variables except gender significantly affect the adaptation strategies.

In the following section, only the variables that were statistically significant at less than or equal to 10% probability levels are interpreted and discussed. The results specified in table 7 below that the age of the HH heads had significant effects on the choices of adaptation strategies. Specifically, the results show that age of the HH was found to be positively and significantly correlated with terracing for soil and water conservation and income diversification with improved variety at $p \leq 0.1$ compared with the base category.

Table 7. Parameter Estimates

| Smallholder farmers' choice and actual adaptation strategies [a] | | B | Std. Error | Wald | df | Sig. | Exp(B) | 95 and 90% Confidence Interval for Exp(B) Lower Bound | Upper Bound |
|---|---|---|---|---|---|---|---|---|---|
| Terracing for soil & water conservation | Intercept | .317 | 90.717 | .000 | 1 | .997 | | | |
| | Education | 2.733 | 1.213 | 5.079 | 1 | .024 | 15.376 | 1.428 | 165.568 |
| | SEF3 | -1.915 | 1.071 | 3.198 | 1 | .074* | .147 | .018 | 1.202 |
| | SEF4 | -3.129 | 1.164 | 7.225 | 1 | .007 | .044 | .004 | .429 |
| | PSyF1 | 1.651 | .523 | 9.959 | 1 | .002 | 5.215 | 1.870 | 14.544 |
| | IF3 | -1.431 | .364 | 15.429 | 1 | .000 | .239 | .117 | .488 |
| | IF4 | -2.008 | .735 | 7.460 | 1 | .006 | .134 | .032 | .567 |
| Fertilizer application | Intercept | -17.29 | 527.008 | .001 | 1 | .974 | | | |
| | IF1 | -.830 | .394 | 4.443 | 1 | .035 | .436 | .202 | .943 |
| Livestock diversification with supplementary feed | Intercept | -45.42 | 162.667 | .078 | 1 | .780 | | | |
| | Size | .782 | .438 | 3.184 | 1 | .074* | 2.187 | .926 | 5.164 |
| | Farming | -1.096 | .565 | 3.759 | 1 | .053* | .334 | .110 | 1.012 |
| | Education | 4.408 | 1.306 | 11.395 | 1 | .001 | 82.085 | 6.350 | 1061.049 |
| | IF4 | -3.069 | .820 | 14.005 | 1 | .000 | .046 | .009 | .232 |
| Using irrigation | Intercept | -70.09 | 653.384 | .012 | 1 | .915 | | | |
| | Size | -.965 | .485 | 3.958 | 1 | .047 | .381 | .147 | .986 |
| | SEF2 | 2.378 | .847 | 7.882 | 1 | .005 | 10.785 | 2.050 | 56.737 |

❖ SEF2= Land ownership, SEF3= Crop production, SEF4= Livestock ownership, PSyF1=Farmers perception to climate change and land size, IF1= Access to information,IF3= Access to credit and IF4= Access to market

a. The reference category is: No adaptation.
b. Floating point overflow occurred while computing this statistic. Its value is therefore set to system missing.
c. * signify level of significance at 10%. Source: Own computation from survey data, 2021

Table 8. Classification

| Observed | 1 | 2 | 3 | 4 | 5 | 6 | Percent Correct |
|---|---|---|---|---|---|---|---|
| 1 | 39 | 3 | 0 | 19 | 6 | 0 | 58.2% |
| 2 | 4 | 15 | 0 | 6 | 0 | 0 | 60.0% |
| 3 | 0 | 0 | 14 | 0 | 0 | 0 | 100.0% |
| 4 | 9 | 7 | 0 | 62 | 14 | 0 | 67.4% |
| 5 | 5 | 0 | 0 | 3 | 49 | 3 | 81.7% |
| 6 | 10 | 4 | 0 | 13 | 3 | 9 | 23.1% |
| Overall % | 22.3% | 9.7% | 4.7% | 34.3% | 24.0% | 4.0% | 63.7% |

1=Terracing for soil and water conservation,2= fertilizer application,3= income diversification, 4=livestock and crop diversification, 5=using irrigation and 6= crop diversification with improved variety

➢ **Education level of the household head**: Grounded on the result of the MLR model, the education level of the household head found to be significant influence on terracing for soil and water conservation. Farmers who have more education level were more likely to adapt to climate change using terracing for soil and water conservation than those who do have lower education level. This result might originate from the fact that education improves farmers" capacity of obtaining and analyzing new information about climate change and best adaptation practices that increases the probability of adapting to climate change. More specifically, it equipped farmers with knowledge of selecting appropriate terracing for soil and water conservation. Various studies reported relationship between education and terracing for soil and water conservation. The result is consistent with Solomon et al. (2016), Gadédjisso-Tossou (2015) and Adeoti et al. (2016) that confirmed as the educational level of the household head increases, the level of understanding about climate change adaptation increases so that likelihood of using drought tolerant and short season variety increases. Abrham et al. (2017) and Abid et al. (2015) also noted that education has a positive influence on the use of SWC practices because it is likely to enhance farmers‟ ability to receive, interpret and comprehend information relevant to make innovative decision in the farms.

- **Crop production**: Grounded on the result of the MLR model, the crop production of the household head found to be significant influence on terracing for soil and water conservation. Farmers who have more knowledge on crop production were more likely to adapt to climate change using terracing for soil and water conservation. This result agrees with of Solomon et al. (2016) also noted that absence of terracing for soil and water conservation significantly affected crop production in response to climate change which supports this finding.
- **Livestock ownership**: Ownership of livestock is also statistically significant and negatively associated with terracing for soil and water conservation. Farmers who have large number of livestock in tropical livestock unit are less likely to respond to climate change using terracing for soil and water conservation. The possible conviction is that since farmers use traditional way of livestock husbandry system, it competes for land, time and labor with crop production. Cattles are also likely to destroy terraces and soil bends. In addition, ownership of large livestock implies the farmer is affluent and has alternative source of income so that he or she would give less attention for crop production. Therefore, he or she participated less in terracing for soil and water conservation. This result is the same with the work of Abrham et al. (2017) which revealed that owning large number of livestock in tropical unit increase farmers‟ likelihood of using terracing for soil and water conservation.
- **Farmers' perception to climate change and land size**: Farmers perception to climate change and land size significantly and positively affected using of terracing for soil and water conservation and using irrigation. The bigger the land size, the more likely the farmer is to adopt terracing for soil and water conservation. The possible reason is that farmers who have bigger farm size have an option to divide their farm into different enterprises. According to the focus group discussions, they reach at a consensus that farmers who have a very limited land size could not use terracing for soil and water conservation. It is mostly because they produce consumption goods on the farm they have. In addition, the farm of some households with small landholding may have higher probability of not better suited for use of terracing for soil and water conservation. This finding agrees with the result found by Nhemachena and Hassan (2007) that noted an increase in land size increases the likelihood of applying terracing for soil and water conservation in response to climate change.
- **Access to credit**: Grounded on the result of the MLR model, access to credit has a statistically significant positive effect on using of terracing for soil and water conservation. Farmers who have access to credit are more likely to adapt climate change by using these adaptation strategies. It enables farmers to change their management practices in response to changing climatic factors and to buy materials for terracing for soil and water conservation and reduce the negative impact of climate change. It is also consistent with the work of Nhemachena and Hassan (2007) that strongly advocated the positive effect of access to credit on the probability of adopting irrigation, terracing for soil and water conservation, adjusting planting date, and using different crop variety in response to climate change by strengthening their financial capacity.
- **Access to market**: Access to market significantly and positively affected using of terracing for soil and water conservation and livestock diversification with supplementary feed. Farmers who have access to market are more likely to adapt climate change by using these adaptation strategies.
- **Access to information**: Access to information significantly and positively affected using of terracing for soil and water conservation. Farmers who have access to climate related information from different media like radio and television have a higher probability of using terracing for soil and water conservation as an adaptation strategy in response to climate change. Most likely, the reason is that access to climate information permits to perceive the change and choose appropriate strategies in response to climate change. Climate information notifies the situation of the existing climatic conditions to enable the farmers to use alternative adaptation strategies like drought tolerant variety and irrigation. It is also supported by Gebru et al. (2015) that confirmed access to climate information increases the use of terracing for soil and water conservation. From the focus group discussion, radio is the major source from which farmers obtain climate related information.
- **Farming experience**: Based on the result of the MLR model, Farming experience was found to be statistically significant related to livestock diversification with supplementary feed.More specifically, it informs farmers when to sow and what variety to use in response to climate change. In agreement with this finding, the study by Temesgen et al. (2009) showed that extension service increases the chance of using improved variety and adjusting planting date in response to climate change. Moreover, Abid et al. (2015), Gebru et al. (2015) and Aemro et al. (2012) also confirmed that extension visit enhances the likelihood of using improved variety.

The MNL model shown that different factors were found to be statistically significant related to terracing for soil and water conservation, fertilizer application, livestock diversification with supplementary feed and using irrigation at $p \leq 0.1$ and 0.05 that is .024, .074, .007, .002, .000 and .006 for education, crop production, livestock ownership, farmers perception to climate change and land size, access to credit and access to market respectively

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for terracing for soil and water conservation. Access to information was found to be statistically significant related to fertilizer application at $p \leq 0.05$ that is 0.035. In addition to this, size, farming, education and access to market at $p \leq 0.1$ and 0.05 that is 0.074, 0.053, 0.001 and 0.000 respectively were found to be statistically significant related to livestock diversification with supplementary feed.

## 5. CONCLUSION AND RECOMMENDATION

### 5.1. CONCLUSION

Developing countries like Ethiopia in which a large proportion of the population is heavily dependent on agriculture; climate change has adversely affected the livelihoods of people. Different studies showed that rise in temperature and rainfall failures resulting in severe food insecurity. Famines in Ethiopia are mainly due to significant loss of crops and livestock resulted from climate change. Thus, farmers should be able to adapt to reduce the undesirable impact of climate change. To avoid food insecurity and for better future, a better understanding on the level of perception of farmers to the changing climate and the common adaptation strategies with their determinants is a key as it permits to policy makers to craft a host of strategies and instruments towards falling climate change hazard.

The general objective of the study is to assess the actual smallholder farmers' choice and adaptation strategies to climate change in the study area. To achieve the objectives, daily meteorological and primary data generated from FGD, key informant such as elder people and employees of Abala Abaya and ADAFPO were used. Abala Abaya is selected due to high exposure to droughts, weak adaptive capacity, high level of food insecurity problems, high potential for crop production and etc.

For this study, simple random sampling techniques were employed to select the sample of respondent households. First, among rural kebeles, four rural kebeles were selected, using simple random sampling technique. 94 respondents were included in this study. Then using probability proportion to sample size techniques household heads was randomly selected. Finally, the sample size of the respondents was determined by using Kothari (2004). Both primary and secondary data were used for the study. The primary data was collected from households directly through interview. The secondary data was collected from different published documents, publications, official reports, and different documents from any relevant organizations. In this study, both descriptive and multinomial logistic regression model were used to analyze the data.

The results showed that majority of the smallholder farmers employed different adaptation strategies to adapt to adverse effects of climate change including tracing for soil and water conservation, fertilizer application, livestock and crop diversification and using irrigation. The results further revealed that although the local people employed different strategies to adapt the adverse effects of climate-induced shocks, there were constraints that limit the HH's adaptation strategies. These include lack of finance, shortage of land, lack of information and mass media, lack of skill and education and shortage of labor.

The MNL model shown that different factors were found to be statistically significant related to terracing for soil and water conservation, fertilizer application, livestock diversification with supplementary feed and using irrigation at $p \leq 0.1$ and 0.05 that is .024, .074, .007, .002, .000 and .006 for education, crop production, livestock ownership, farmers perception to climate change and land size, access to credit and access to market respectively for terracing for soil and water conservation. Access to information was found to be statistically significant related to fertilizer application at $p \leq 0.05$ that is 0.035. In addition to this, size, farming, education and access to market at $p \leq 0.1$ and 0.05 that is 0.074, 0.053, 0.001 and 0.000 respectively were found to be statistically significant related to livestock diversification with supplementary feed.

### 5.2. RECOMMENDATION

The result of this study is based on the purposively selected four kebeles. Yet, it is often recommended to apply different kebeles so as to make comparison as well as to explore a wide range of climate change that would result in different climatic impacts. Hence, the local decision makers such as agricultural sector, microfinance sector, and meteorological agency should provide farmers with credit access and climate information access to reduce shortage of finance and lack of climate information. There is also a need to provide farmers with training on improved agricultural technology and market access to enhance their climate resilience. There is a need to promote appropriate adaptation measures. Henceforth, it is critical to promote these adaptation strategies to reduce the adverse impacts of climate variability in this study's sites.

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