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Adaptation Strategies and Perception of Smallholder Farmers to Climate Change: The Case of Wera Sub-Watershed in Anlemo District, Central Ethiopia

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Abstract

The agricultural sector remains the main source of livelihood for rural communities in Ethiopia but faces the challenge of changing climates. This study aims to assess smallholder farmers' perception and adaptation strategies as determinants of climate change. Both primary and secondary data were used. The primary data were collected from 130 randomly selected households for interviews and secondary data were also gathered from the Analemo District agricultural and rural development office. In addition, temperature and rainfall data for the period 1995-2014 were also gathered from National Meteorological Agency Hawassa sub-office. A frequency distribution analysis was used to summarize farmers' perception, see the actual rainfall and temperature, and identify the different adaptation responses to climate change. A multinomial logit (MNL) model was used to identify determinants affecting farmers' choice of adaptation strategies in response to climate change. The descriptive statistics results showed that 83.9% and 59.2% of the respondents perceived the existence of climate change in terms of temperature and rainfall, respectively. The statistical analysis also indicated that sex of households, household size, soil fertility, market distance, access to agricultural extension services, access to credit, land holding size, educational status, and livestock holding size have significant influence on the choice of climate change adaptation strategies. Generally, the choices of adaptation strategies used by smallholder farmers need to be capitalized to best responding to the existing climate change.

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Introduction

Climate change is defined as a change in the climate that can be directly or indirectly linked to human activities and that modifies the global atmospheric composition as seen over similar time periods (IPCC, 2014). This transformation becomes a significant worldwide issue since it poses a significant threat to the global population. It has an impact on market conditions, infrastructure, food and water security, and human and animal health (Charles *et al*., 2014). Because most of these nations' primary source of income is rain-fed agriculture, which depends on climatic conditions, developing countries, particularly Africa, are the most vulnerable to the detrimental effects of climate change (Serdeczny *et al*., 2017). The vulnerability of African nations is additionally exacerbated by a lack of social, economic, and financial resources, which limits their capacity to mitigate and adapt to the effects of climate change. Ethiopia is vulnerable to climate change because its main economic sector is reliant on agriculture and it is a part of Africa.

3.7 million hectares of Ethiopia's 5.3 million hectare irrigation potential can be used for irrigation crops using surface water sources. Ethiopian agriculture is still rain-fed and subsistence-based, notwithstanding the potential for irrigation development (Zewdie *et al*., 2021). Additionally, roughly 74% of Ethiopian farmers are smallholders who grow mostly for their own consumption and a tiny amount of surplus that is sold on the market (FAO, 2018). The majority of Ethiopia's smallholder farmers harvest their crops on extremely tiny plots of land using a traditional approach, which limits their ability to invest in more efficient farming techniques that could lessen their susceptibility (USAID, 2017).Ethiopia's climate is projected to continue warming, but rainfall patterns are quite unpredictable (NAPA, 2019).

According to the IPCC's mid-range emission scenario, the mean annual temperature will rise by 2030, 2050, and 2080 on average, compared to the average between 1961 and 1990, by 0.9°C. In addition, research on climate trend analysis in various regions of the nation (Ademe *et al*., 2020), using data from 40 and 35 years of rainfall and temperature, respectively, revealed a mixed pattern of rainfall and an increasing trend of temperature. Higher frequency of extreme events, increasing temperature, change in rainfall, the occurrence of new pests and diseases resulting from climate change are challenging the livelihood of smallholder farmers in Ethiopia (Tesfaye and Seifu, 2016). Drought was one of the climate extremes that significantly harmed farmers in rural areas who relied on rainfall. 10.2 million People experienced food insecurity as a result of the recent drought that began in 2015 and resulted in catastrophic animal losses and crop failures (FAO, 2016). This change's unfavorable effects are occasionally getting worse and have exposed many smallholder farmers who are short on resources (Asrat and Simane, 2017).

Smallholder farmers' livelihoods are impacted by climate change since it lowers crop yields and risks their level of food security (Yalew *et al*., 2017). By 2050, climate change may lower agricultural production by 6% annually and the national gross domestic product by 8%–10%, respectively, according to USAID (2017); however, agricultural adaptation measures may be able to halve losses. Making the agricultural sector climate-adaptive is therefore a top concern for Ethiopia because the majority of the population depends on it. According to Franklin *et al.* (2012) adaptation to climate change in agricultural output refers to adjustments in farming practices to go with climatic circumstances that lessen the potential negative impact. This will help smallholder farmers to secure their income and reduce their vulnerability. Therefore, identifying adaptation strategies used by smallholder farmers and factors that affect their choices of adaptation strategies is vital in designing policies to promote effective adaptation options in Ethiopia in general and to improve the adaptive capacity of smallholder farmers in particular.

Perceiving climate change is the leading step in the process of adapting agriculture to climate change

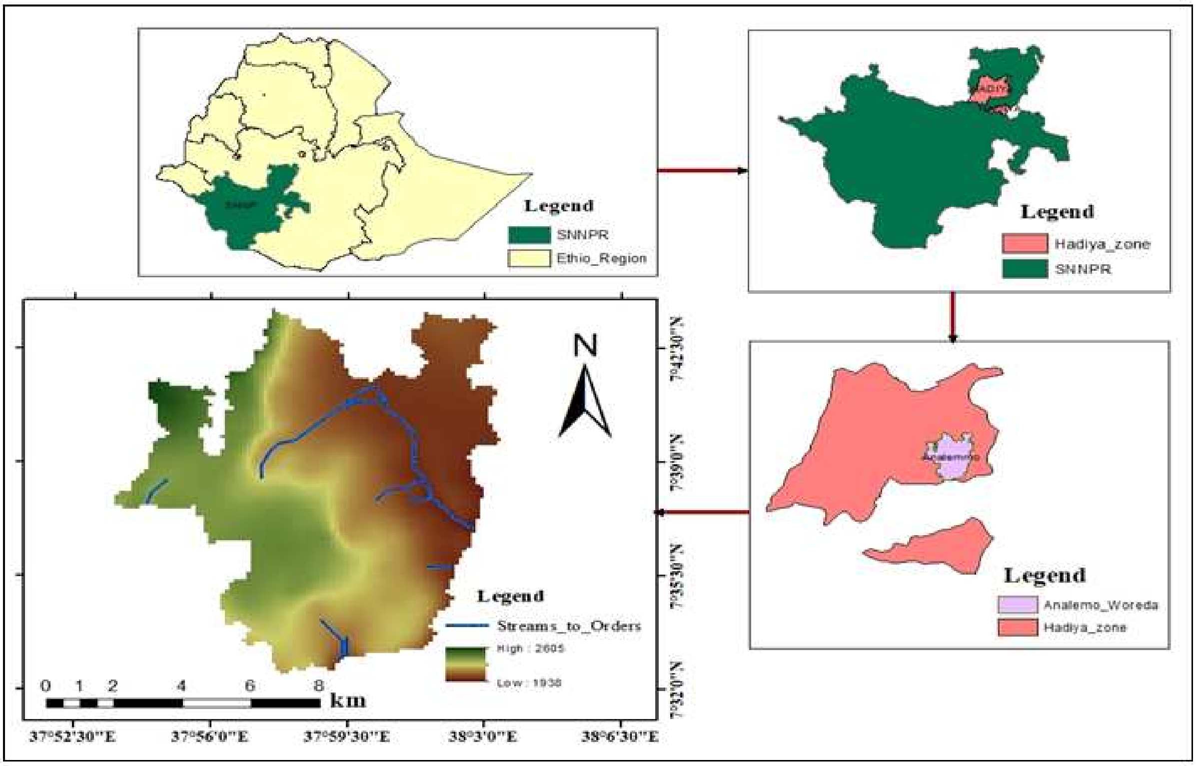
(Temesgen *et al*., 2011). Knowing of farmers concerns and the manner in which they perceive climate change is crucial to offer effective policies for supporting successful adaptation of the agricultural sector. Further, it is also important to have precise knowledge about the type and extent of adaptation methods being taken up by farmers and the need for further advances in existing adaptation set ups. Hence, understanding how farmers perceive changes in climate and what factors shape their adaptive behavior is useful (Weber, 2010). But previous studies have failed to consider the perception of smallholder farmers and adaptation strategies. Therefore, an attempt was made in this study to assess smallholder farmers' perception and adaptation strategies to climate change. The research questions considered include: (1) how do farmers perceive climate change in the study area? (2) What kind of adaptation strategies are used by farmers in response to climate change in the study area? (3) What are the determinants of farmers' adaptation strategies to climate change in the study area?

Materials and methods

Description of the study area

This study was conducted in Anlemo District, Hadiya Zone, in central Ethiopia. Geographically, it is located between latitudes 7° 54′ 7.7′′N and 37° 89′ 38.06′′E (Fig. 1). Topographically the study area is characterized by steep slopes, moderately gentle lands and flat plains in certain areas. The District is 210 km from Addis Ababa and 18 km from Hosanna, which is the capital town of Hadiya Zone.

The district is found "Weynadega" agro-climatic zone with altitudinal ranges of 1937 - 2576 m.a.s.l. It has a cool temperature range 15°C - 20°C, and the District received 1001-1200 mm of mean annual rainfall.



(Source: Ethio-GIS data using ArcGIS10.8)

Fig. 1. Map of the Study Area.

There are three dominant soils in the Analemo District. These are Lithic Leptosols, Chromic Luvisols and Vitric Andosols. These soils are of volcanic origin, and are often over a sedimentary base. Though inherently well drained and fertile, they are also acidic and highly erosion-prone and as a result the agricultural areas are often highly degraded. The soils on the study area have been cleared of perennial vegetation in the past and due to the steep terrain are highly eroded, resulting in the regular impact of flash flooding and mudslides to the villages below in the wet season (ADARDO (Anlemo District Agricultural and Rural Development Office), 2017). The common vegetation in the study area includes: *Croton macrostachyus, Cordia africana, and Podocarpus falcatus*.

The dominant land-use types in the district are mixed farming. The average land holding in the District is less than a hectare. However, land shortage for cultivation is the main constraint faced by farmers in the region. The farming system also integrates livestock, mainly small stock. During the rainy season, the animals are kept in the proximity of the homesteads, as enough fodder is readily available. However, during the dry season, livestock are left to freely graze the harvested fields. Individual plots are often intersected with shrubs and trees, mainly Eucalyptus. Some Eucalyptus plantations also exist in part of the District, the wood is commonly used for house construction, as well as firewood (ADARDO (Anlemo District Agricultural and Rural Development Office), 2017).

Data Collection

For this study wera sub-watershed was selected using the purposive sampling method because it is affected by climate change, like recurrent unpredictable rainfall and the erratic nature of rainfall. Three representative kebele (Mento, Shesha, and Dulancho) were selected for this study. The same number of respondent was chosen from each kebele. The sample size for this study was computed using Cochran formula *i.e.* $no = \frac{z^2pq}{e^2}$ and n = $\frac{no}{1+(\frac{no-1}{N})}$ Where: no = is the desired sample size, *z* = standard error associated with the chosen levels of confidence (typically 1.96) *p*= variability /standard deviation (it can be taken from previous studies or pilot study) *q*= 1-p *e*= acceptable sample error *N*= total number of population 130 households were selected for questionnaire interviews. The household units for each kebele were obtained from its respective administration body. Majority of the population is engaged in agricultural economic activities and has a homogeneous lifestyle in their livelihood; and for this, a simple random sampling technique was used to select 130 respondents.

For this study, both primary and secondary data were used. For the primary data, semi structured and structured questionnaires were used to collect data from 130 sample respondents. Three focus group discussions (FGDs) (one for each kebele) which consisted of 6–8 participants were conducted. How to understand the status of the perception of climate change, identify current adaptation strategies, and assess the determinant factors of adaptation strategies and barriers to implementing different adaptation strategies in the study area. The key informants were conducted with three local leaders, three model farmers and two development agents totally eight informants were participated from each sampled kebele. Climate data and documents from Anlemo District Agricultural Rural Development Office were source of secondary data. 19 years rainfall and temperature data for the period 1995-2014 have been collected from the National Meteorological Agency (NMA) branch office in Hawassa.

Data analysis

The Data collected from sampled households were coded and then analyzed using Statistical Package for Social Sciences (SPSS) version 26. The data were summarized and descriptive statistics analysis (including frequency and percentage) was conducted and results interpreted accordingly.

In addition, the multinomial logistic regression model was also applied to identify the determinants of adaptation to climate change practices of the smallholder farmer because The multinomial logit model (MNL) is straightforward, simple in calculating the choice probability, and expressible in analytical form (Tse, 1987). The main limitation of the model is the independent of irrelevant alternative (IIA) property, which states that the ratio of the probability of selecting any two alternatives is independent of the attributes of any other alternative within the choice set (Tse, 1987; Hausman and McFadden, 1984). The multinomial probit (MNP) model specification for the discrete choice model does not require the assumption of the IIA (Hausman and Wise, 1978). Due to the fact that this MNP model is an inconvenient specification test as compared to the MNL model (Hausman and McFadden, 1984), The MNL model is employed by many researchers to model the climate change adaptation practices of smallholder farmers (Deressa *et al.,* 2009; Hassan and Nhemachena, 2008).

This random utility model is usually used as a framework for determining farmers' choices for various adaptation options. We can specify a typical formulation of a linear random utility model as follows:

$$U_{ij} = \beta_j X_{ij} + \varepsilon_{ij} \text{ for } j \in J \quad (1)$$

Following Greene (2003), we can modify it to adapt to the objective of the study. Where i = 1, N is the individual farmer, and j = 1, J is the alternative adaptation method; Xij vectors are the factors that influence farmers' choice of an adaptation method to climate change; and eij is the random error term or disturbance term. To elaborate the model, we assume that farmers are rational decision-makers who maximize the utility of adaptation strategies in their farming activities. Also, assuming that farmers face climatic change in their farming activities, they should rummage around for adaptation strategies. If farmer i make choice j adaptation particular, then we assume that Uij is the maximum utility among the J adaptation methods.

Prob ($U_{ij} > U_{ik}$) for all other $k \neq j$.

The probability that a particular farmer will choose a specific alternative j is given by the probability that the utility of that alternative to the farmer is greater than the utility to that farmer of all other alternatives. To describe the multinomial logit model, let Y denote the vector of adaptation options for climate change chosen by farmer households. Assuming the adaptation option that farmers' choice depends on climatic factors, institutional factors, and socioeconomic characteristics of the farmers, the multinomial logit model for the adaptation choice can be specified as in the following relationship between the probability of choosing option and a set of explanatory variables X Greene (2003).

$$\text{Prob}(Y_i = j) = \frac{e^{\beta_j x_i}}{\sum_{k=0}^{J} e^{\beta_j x_i}} \quad j = 0, 1, 2.......3 \quad (2)$$

Equation (1) is normalized to get rid of indeterminacy within the model by assuming β0 = 0, and therefore the probabilities may be estimated as:

$$\text{Prob}\left(Y_i = \frac{j}{x_i}\right) = \frac{e^{\beta_j x_i}}{1 + \sum_{k=0}^{J} e^{\beta_k x_i}} \quad \text{if } k \neq 0 \quad (3)$$

Variables included in the analysis

Independent variables are factors that affect the choice of adaptation methods for climate change. Different literatures are reviewed on the determinants affecting farmers' choices of adaptation methods to climate change. Based on the literature, the independent variable employed were: Sex of households, Education status, Household size, Household size, Access to credit, Extension services, Land holding size, Soil fertility, Livestock holding size, Distance to the market and Access to climate information that influence farmers' choice of adaptation strategies to climate change.

The dependent variables of this study are the adaptation options that the farmers employ in response to climate change. These are: (1**)** Improved crop and crop diversification, (2) Soil and water conservation (SWC)**,** (3) Tree planting, (4**)** Irrigation and, (5**)** Adaptation to climate change.

Before carrying out the final model regressions, all the hypothesized explanatory variables were checked for some statistical fitness, like the issue of multicollinearity. There are different methods suggested to detect the existence of a multicollinearity test between the model explanatory variables. Among these methods, the Contingency Coefficient (CC) were employed to detect multicollinearity for continuous explanatory variables.

Ethical considerations

The studies involving human participants were reviewed and approved by College of Agriculture and Environmental Science Ethics Review Committee, Wachemo University. The participants provided their written informed consent to participate in this study.

Results and discussion

Demographic Characteristics of the Respondents

According to the survey of the households, the majority of the respondents are men (73.8%), and only 26.2% of households are headed by women due to natural and social-related factors, including death and separation of the couples. With respect to age, as indicated in Table 1, the majority of the respondents' ages of the sampled households are generally within the productive age range. Younger farmers have been found to be more knowledgeable about better practices and may be more willing to take risks and adapt to better farming techniques because of their longer planning horizons. Education may play an important role in adopting a new system of farming. As farmers acquire more education, their ability to obtain, process, and use information improves. Education increases the ability of farmers to use their resources efficiently, and the earmark effect of education enhances farmers‟ ability to obtain, analyze, and interpret information.

Table 1. Demographic characteristics of smallholder farmers (n= 130).

Variables	Respondents (n=130)	Percent (%)
Sex		
Male	96	73.8
Female	34	26.2
Age(years)		
32 -47	72	55.4
48 -63	32	24.6
>64	26	20.0
Level of education		
No formal education	36	27.7
Primary	55	42.3
Secondary	39	30.0
Farming experience(years)		
10 -30	89	68.5
31 -51	38	29.2
> 52	3	2.3
Duration of the stay in study area		
20 -35	91	70.0
36 -50	27	20.8
>51	10	9.2

(Source: Survey result, 2023).

Table 1 shows that the farmers have a good level of education, which has a significant impact on the practices of modern climate change adaptation strategies because a minimum threshold qualification is necessary for the activities related to climate change adaptations.

Also, results presented in Table 1 showed that farmers‟ perception and awareness of climate change could also be influenced by the number of years of farming experience, as more experienced farmers would have the tendency to detect long-term climate shifts. The duration of the stay in the study area has significant implications for identifying the historical profile of climate change and its adaptation practices (Table 1). This appears to be logical to collect data pertinent to climate change and its adaptation practices from communities that have lived in the area for longer periods of time.

Smallholder Farmers' Perception of Climate Change

In general, in the study area sample household perceptions of climate change are based on what people observe in their local environment (such as changing temperatures and rainfall patterns). This is because, as a result of the higher rainfall fluctuation in terms of decrease rainfall, increase rainfall and erratic rainfall in recent years, farm households have well perceived climate change. The finding agreed with the result of Ndak's (2014) study of smallholder farmers‟ perception of the changes in the local climate, and the main reference to these changes is rainfall. This is because rainfall supports smallholder farmers because their production on the farm is mainly rain-fed.

Perception on temperature changes

In the study area over the last 19 years showed an increasing trend based on the linear fitted line of average annual temperature on times in years, there is a general increase in the average annual temperature distribution in the study area the data for temperature showed that temperature is increasing. The trend analysis between average annual temperatures over time indicated that average temperature in the study area increases on average about 0. 0589°C (Fig. 2).

Table 2. Perception of farmers on annual average temperature during the last 19 years.

Perceived change	Number of respondents	Percent (%)
Increased	109	83.9
Decreased	11	8.5
I do not know	10	7.6

(Source: Survey result, 2023).

On the other hand, In the past 19 years, smallholder farmers of perceived and observed temperature variability and change, such as about 109(83.9%) of the respondents perceive as the temperature had increased, about 11(8.5%) as it had decreased, and about 10(7.6%) respond they do not know about the change of temperature (Table 2). Accordingly, this implied that the perception of majority of the respondents is in line with the fitted line for the data obtained from NMA and hence showed that farmers‟ actually perceived the presence of climate change considering temperature as one attribute.

Table 3. Perception of farmers on annual average rainfall during the last 19 years.

Perceived change	Number of respondents	Percent (%)
Decrease rainfall	77	59.2
Increase rainfall	23	17.7
Erratic rainfall	12	9.2
I do not know	18	13.1

(Source: Survey result, 2023).

Adeoti *et al.* (2016) also found that 84% and 72% of respondents perceived the increase in temperature in their particular study areas.

Perception on rainfall changes

In the study area over the last 19 years showed that there is a slight decrease. The trend analysis of average rainfall over time indicated that decreases 9.6417mm distribution across years (Fig. 3). Concerning the result from the survey, 77(59.2%) of the respondents recognized that there is a decrease in rainfall. In addition, 23(17.7%) of the respondents perceived that there is increased availability of rainfall while the remaining 12(9.2%) and 18(13.1%) believed that there is erratic rainfall availability and I do not know respectively (Table 3). The result from the survey assured that majority 83(63.8%) of the respondents perceived as there is a decrease in rainfall which is in agreement with the study of Debela *et al.*, (2015) stated that 87% and 94% of respondents perceived the decrease in rainfall in their respective study areas. However, according to NMA data, in addition to the decrease in rainfall, erratic nature of rainfall availability is the key climatic problem. Irregularity in rainfall distribution among months and years is the major change observed. Therefore, it can be concluded that farmers' perception on the decrease in rainfall availability is right even though its irregularity is also the key challenge and which did in fact recognized by them.

Table 4. Variables and effects on adaptation to climate change.

Independent Variable	Category	Dependent or Response Variables=Adaptation to Climate Change							
		Crop diversification, improved crop variety		Small scale irrigation		Planting tree		SWC	
		Coeff.	P-value	Coeff.	P-value	Coeff.	P-value	Coeff.	P-value
Sex of households	Male	-0.821	0.427	0.094	0.945	0.346	0.762	17.990	0.000***
	Female								
Education status	No education	2.01	0.65	4.815	0.007***	4.6	0.629	1.64	0.740
	Primary	1.7	0.81	1.9	0.430	0.272	0.810	1.8	0.670
	Secondary								
Land holding size	Continuous	1.791	0.079*	1.913	0.076*	0.598	0.561	0.895	0.390
Household size	Continuous	-0.201	0.492	-0.028	0.937	1.795	0.040**	0.143	0.035**
Livestock holding size	Continuous	-1.488	0.067*	-0.244	0.375	0.139	0.594	-0.286	0.305
Soil fertility	Low	2.648	0.097*	1.082	0.446	15.904	0.998	8.805	0.000***
	Medium	1.904	0.120	0.500	0.588	0.747	0.559	1.001	0.430
Market distance	Continuous	0.135	0.226	0.057	0.673	0.103	0.404	0.336	0.012**
Access to credit	Yes	19.759	0.000***	22.219	0.000***	1.81	0.230	1.701	0.129
	No								
Access to climate information	Yes	2.408	0.020**	1.085	0.400	1.188	0.291	0.913	0.414
	No								
Access to extension services	Yes	1.022	0.215	2.547	0.013**	2.053	0.023**	3.81	0.000***
	No								

Note: ***, **, and * indicate level of significance at 1%, 5%, and 10%, respectively.

(Source: Survey result, 2023).

Smallholder Farmers Climate Change Adaptation Strategies

Based on the results of the household survey, focus group discussions, and key informant interviews with farmers in the Wera sub-watershed, the majority of respondents perceived climate change, which is expressed in terms of erratic rainfall, increase rainfall, shortages of rainfall, as well as an increase in temperature and decrease temperature in the last recent decades. In response to this, the descriptive statistics found that 109(83.8%) of households employed a minimum of one adaptation strategy, among others. Farm households were asked about their major adaptation strategies to tackle or counteract the observed climate change and variability. Thus, the result in (Fig. 4).

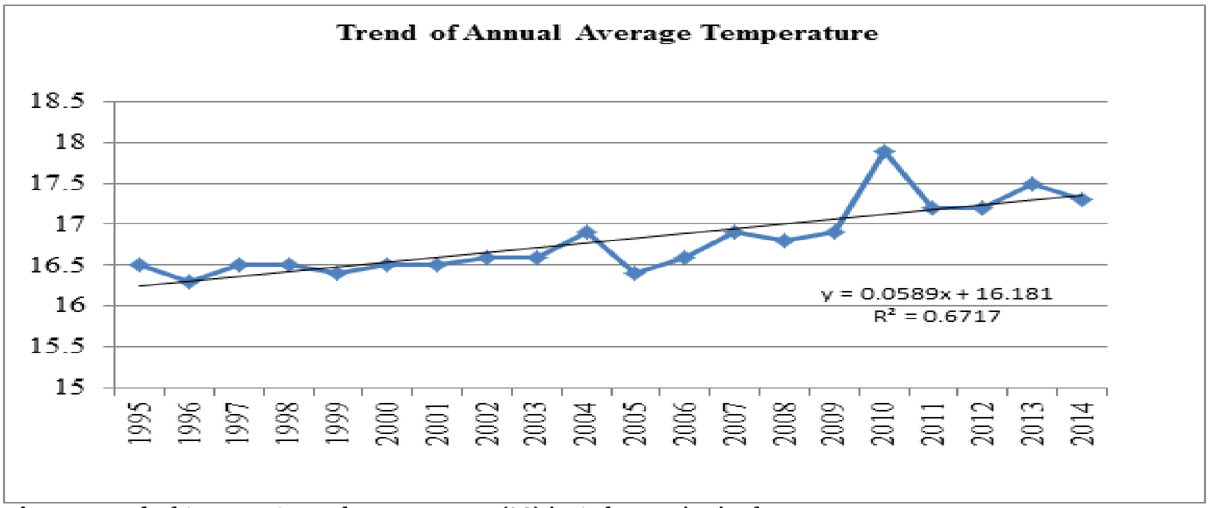


Fig. 2. Trend of Average Annual Temperature (°C) in Anlemo District from 1994-2014.

(Source: Computed from NMA data in Hawassa sub-station).

It was demonstrated that crop diversification and improved seed 34(26.2%), soil and water conservation 39(30%), tree planting 20 (15.4%), and small-scale irrigation 22(16.9%) were identified and practiced as the major adaptation strategies by farm households in the study area. This result is in line with the findings of Juana *et al.*, (2013), Deressa *et al.*, (2009), Deressa *et al.*, (2008; Tessema *et al.*, (2013), Bewket (2010), and Temesgen (2010), which indicated that crop diversification, planting different crop varieties, changing planting and harvesting dates, irrigation, planting tree crops, and water and soil conservation techniques are the major adaptations to the changing pattern of precipitation.

Barriers of climate change adaptation strategies

Barriers are the interaction of a complex of factors that influence adaptation. From this, it is apparent that barriers are the result of the interaction of a complex of factors that influence adaptation.

Respondents in the study area who did not use adaptation strategies have given many reasons, which include a shortage of farm land, a lack of formal credit, a lack of improved seeds, a lack of climate forecasting information, and a lack of infrastructure and agricultural input. Among these, lack of formal credit service, lack of climate forecasting information, and shortage of farm land were the major constraints (Fig. 5).

This finding agrees with Debela *et al.* (2015) revealed that in South Ethiopia, farmers with limited access to climate information attribute the extreme weather events to a lack of formal credit. Information obtained from FGDs indicates that lack of formal credit during the shortage of capital is one of the major barriers to adaptation implementation.

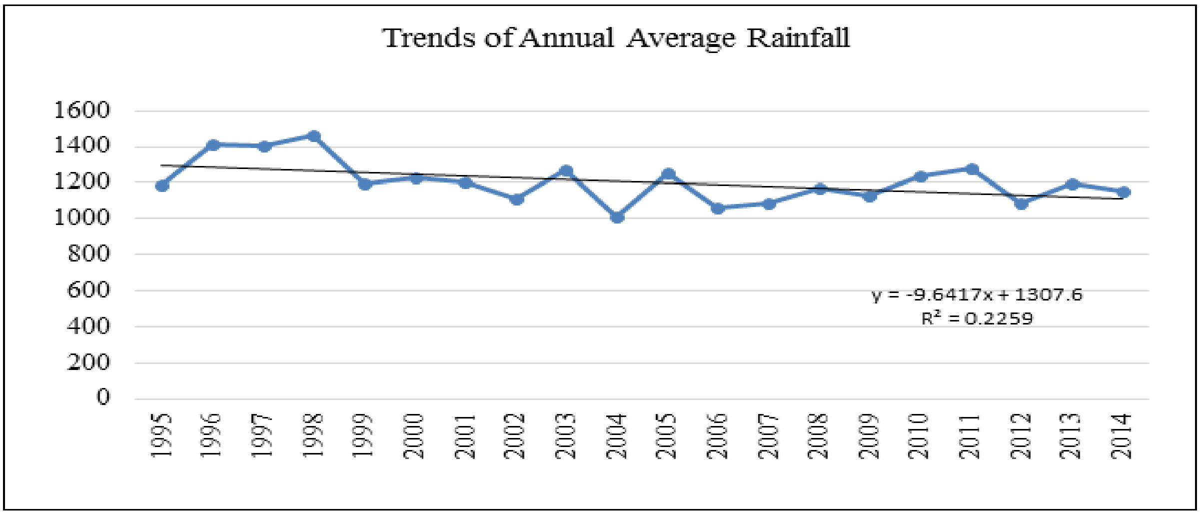


Fig. 3. Trends of average annual rainfall (mm) in Anlemo district from 1995-2014.
(Source: Computed from NMA data in Hawassa sub-station).

Determinants of farmers' adaptation strategies

A multinomial regression model (MNL) was used to determine factors that influence smallholder farmers' choice of climate change adaptation strategies. The Multinomial Logit Model was run taking 'no adaptation' as the base category against which the remaining outcomes are compared with (Table 4).

Before constructing the model to estimate the parameter, we performed different tests to judge the goodness of fit and check the desired assumptions, which are necessary to undertake a multinomial logit model. The model was fitted using Statistical Packages for Social Sciences (SPSS) version 26, and accomplished is a test with assumptions of multicollinearity. Predictor variables like wealth status and farming experience of the respondents were removed from the analysis due to the problems of multi- collinearity and correlation matrix methods prior to running the final regression analysis.

The results of the test indicated that there is no severe problem of multicollinearity among the explanatory variables. In this study (Table 4) the results from the multinomial logit (MNL) model indicated that the sex of the household head positively and significantly influenced the use of soil and water conservation practices. This indicates that male-headed households are most likely to adopt soil and water conservation practices than female-headed households. This result is similar to that of Yousuf *et al.* (2014), who reported that male-headed households are more likely to adopt soil and water conservation practices (SWC) than female-headed households. Thus, because of this adaptation strategy labor-intensive nature, it is less practiced by female-headed households. Education level positively association with small-scale irrigation adaptation strategies, a farmer whose education level with no formal education was more likely to choose small-scale irrigation over no adaptation in reference to secondary education.

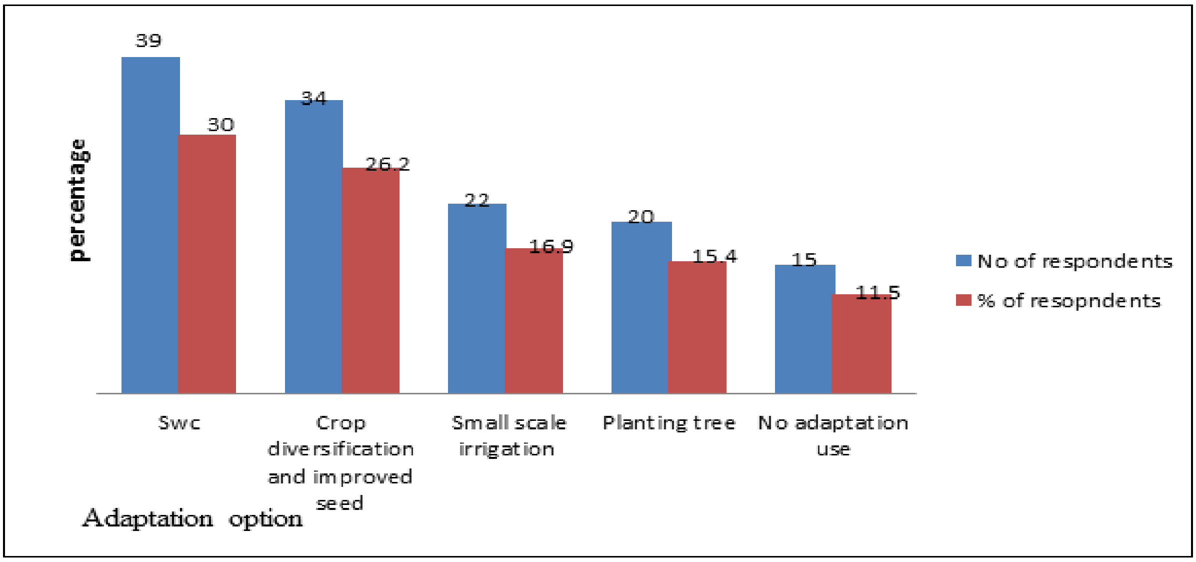


Fig. 4. Adaptation strategies used by smallholder farmers in the wera sub-watershed.
(Source: Survey result, 2023).

The land holdings of the households have a positive and significant impact on the use of small-scale irrigation, crop diversification, and improved crop adaptation strategies. This is because large farm sizes allow for different crops and animals, which is vital to reducing the risks of unpredictable climate impacts. This result is in line with the finding of Yousuf *et al.* (2014), who reported that farmers with large farm sizes use a small-scale irrigation adaptation strategy.

The result presented in (Table 4) revealed that household size positively influenced the choice of tree planting and SWC adaptation strategies. The possible reason could be that large household size is normally associated with a higher labor endowment, which would enable a household to accomplish various agricultural tasks which are labor intensive like soil and water conservation practices. The result agree with Hassan and Nhemachena, (2008) which states that households with larger household size are expected to enable farmers to implement various adaptation measures. Livestock ownership has a negatively influenced the choice to crop diversification and improved crop.

This result reveals that a unit increase in a number of livestock in TLU would decrease the choices of crop diversification and improve crop. This finding is similar to (Seid, 2014) findings indicates livestock ownership has negative and significant impact on use of crop diversification as adaptation strategy. Livestock rearing requires a grazing land which makes livestock competent with crop production.

Soil fertility status of a plot of land has positive and significant influence in SWC adaptation strategies.

The probability of adopting soil and water conservation for farmers perceiving their soil to be low fertile and medium fertile are more as compared to the base category of farmers who perceive their soil is fertile. Distance from the home of a household to the main market was a positive and significant influence on the choice of SWC adaptation strategies. This may be explained by the fact that households in the remote area have less opportunity to adapt labor-intensive adaptation practices (SWC activities like terraces and tree planting). The argument by Deressa *et al.* (2008), in favor of our finding, concurs that households in a remote area may be more willing to take up adaptation in order to reduce climate-related risk, probably due to the availability of fewer income-earning opportunities.

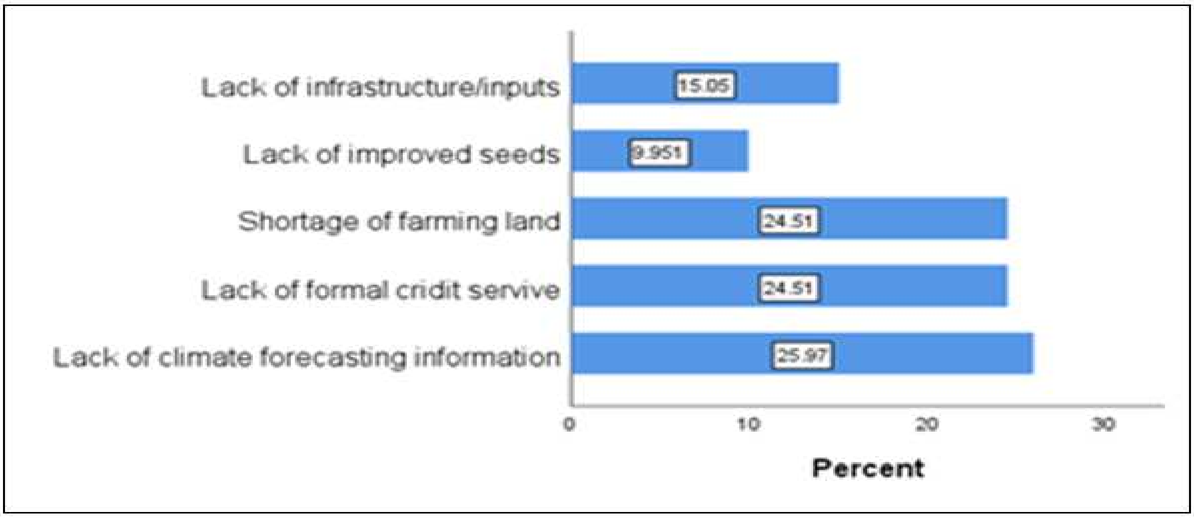


Fig. 5. Barriers of climate change adaptation strategies. (Source: Survey result, 2023).

The result also indicated that household access to credit has a positive and significant influence on small-scale irrigation and crop diversification and improves crop adaptation strategies.

Having access to credit increases the probability of adoption of small-scale irrigation, crop diversification, and improved crops. The possible reason may be that the availability of credit minimizes liquidity constraints and thereby enhances the adoption of small-scale irrigation. This clearly indicates that those farmers who neither have cash nor access to credit are priced out of using small-scale irrigation. Access to affordable credit increases the financial resources of farmers and their ability to meet transaction costs associated with various adaptation options they might want to take (Hassan and Nhemachena, 2008). Access to climate information was positively related to crop diversification and improved crops keeping another variable constant. This implies that farmers who have access to climate information (i.e., rainfall and temperature) increased their use of planting diversified crops in the same plots of land and using different improved crop varieties, such as drought-tolerant and early-maturing crops.

Moreover, access to extension services is has significant influence on tree planting, and small scale irrigation SWC keeping another variable constant. This implies that farmers who have access to extension increased the use of SWC to reduce soil erosion, gully formation, and moisture stress in their soil

Conclusion

It has been shown that the majority of the household respondents perceived the existing climate change in terms of, erratic rainfall, increase rainfall, decrease rainfall, and increase in temperature and decrease temperature over the last few decades. However, there are still a significant number of households that didn't perceive the change yet and did not perceive the erratic nature of rainfall distribution, which was observed as the most prominent change in the study area. Despite the observed climate change and variability the majority of farm households employed at least one adaptation strategy, among others. Soil and water conservation, crop diversification and improved seeds, small-scale irrigation, and planting trees were identified as practices. Some of the sample respondents in this study area have not taken adaptation measures to climate change due to different constraint factors. These include a shortage of farming land, a lack of climate forecasting information, a lack of formal credit service, a lack of improved seed, and a lack of infrastructure and input.

Accordingly, the MNL model result showed that sex, educational level, household size, livestock holding soil fertility, market distance, access to credit, access to climate information, and access to agricultural extension were statistically significant determinants of farmers' choice of adaptation strategies. The level of farmers' perception of climate change has a significant effect on their level of use of adaptation strategies to lessen the effect of climate change. But there are still a considerable number of farmers who do not perceive the changing climate. Therefore, updated metrological information should be available to the local farmers. However, interventions aimed at mitigating the adverse effects of climate change need to focus on supporting farmers to intensively use and capitalize on the existing adaptation strategies: crop diversification and improved seed, planting trees, SWC practices, and small-scale irrigation.

Data availability statement

The datasets presented in this article are not readily available because Ethical clearance given may not permit sharing of datasets with a third party. Requests to access the datasets may be directed to betelhembt47a@gmail.com, john@wcu.edu.et or yohannesh2005@gmail.com

Author contributions

Betelhem Bizuneh (BB) (MSc) Yohannes Horamo (YH) (Ph.D.) and Brehanu Achamo (BA) (MSc): project conception. (BB): data collection, analysis draft and final manuscript writing. (YH) and (BA): supervision and manuscript quality control. All authors contributed to the article and approved the submitted version.

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Conflict of interest

We all authors assure that our research manuscript has not been submitted elsewhere for publication and it is our original work. So that, we all authors would like to confirm that no conflict of interest.

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