DOI: https://doi.org/10.20372/afnr.v2i3. 1347

ISSN: 2520-7687 (Print) and 3005-7515 (Online)
Journal of Agriculture, Food and Natural Resources
J. Agric. Food Nat. Resour. Sep-Dec 2024, 2(3):39-47
Journal Home page: https://journals.wgu.edu.et

Original Research

Farmers' Perception and Adaptation to Climate Change in Western Ethiopia.

Wondimu Saketa[1*] Jema Haji[2] Hussien H. Komicha[3]

[1]PhD. Candidate, Department of Economics, College of Business and Economics, Wollega University, Nekemte, Ethiopia

[2]Professor, School of Agricultural Economics and Agribusiness, College of Agriculture and Environmental Science, Haramaya University, Dire Dawa, Ethiopia

[3]Adjunct Professor, Department of Economics, The University of Winnipeg, 515 Portage Avenue Winnipeg, Manitoba, Canada

Abstract

Ethiopia's agricultural production has been declining due to climate change stresses manifested by extreme weather events, exacerbating food insecurity over the past few decades. The main objective of the study was to investigate farmers' perception and adaptation to climate change using cross-sectional data collected from 588 randomly selected households in western Ethiopia. The study employed descriptive and bivariate probit model to analyze data using STATA software version 15. Notably, about 94% (555) of households perceived climate change as occurring, with decreasing rainfall about 83% (486) and rising temperatures about 85% (498) as key indicators. About 68% (400) of the farmers adopted various adaptation strategies. The bivariate probit model analysis identified common underlying factors significantly affecting both perception and adaptation, including sex, education, family size, farm size, market distance and fragmentation at less than 10% probability levels. However, agro-ecology effect only farmers' perception to climate change at 5% probability level. To enhance farmers' perception and adaptation decision, policymakers should focus on improving education, providing climate information, and strengthening the capacity of farmers to adapt to climate change.

Article Information

Article History:

Received: 18-12- 2024
Revised: 29-12-2024
Accepted: 30-12-2025

Keywords:
Adaptation
Bivariate probit
Climate Change
Perception
Western Ethiopia

***Corresponding Author:**
E-mail:
wondusat@yahoo.com

INTRODUCTION

Climate change significantly impacts global food production and agriculture (Mengistu, 2019). It remains a major challenge worldwide (Hundera et al., 2019; Pedersen et al., 2021), particularly in developing countries where climate-sensitive livelihoods prevail (Asfaw et al., 2021). The Intergovernmental Panel for Climate Change (IPCC) projects a 50% decrease in agricultural output in developing nations due to rising global temperatures (1–2°C) (IPCC, 2014). Climate change has a direct impact on agricultural production, as this sector is highly vulnerable to the risks and consequences associated with global climate change, primarily due to its intrinsic sensitivity to climatic variables (Raghuvanshi & Ansari, 2018).

This is attributed to the substantial variations in temperature and precipitation, which contribute to fluctuations in agricultural yields and overall production levels.

Sub-Saharan Africa, characterized by its dependence on rainfall for agriculture and limited adaptive capacity, is experiencing significant adverse impacts (Matewos, 2019). Agrarian communities within the region are particularly vulnerable to these changes (Kalele et al., 2021). Climate change continues to represent the primary challenge to agricultural development and food security across Sub-Saharan Africa (Araro *et al*., 2019). Ethiopia, with its high reliance on a climate-sensitive economy, is especially susceptible to these challenges (Asrat & Simane, 2018a). In response, global efforts are increasingly focused on mitigating the consequences of climate change and implementing adaptive strategies (Eriksen *et al*., 2021).

Agriculture serves as the backbone of Ethiopia's economy, providing food, employment, and income for the majority of its population. The sector contributes approximately 34% to the national GDP, employs 67% of the labor force, and accounts for 80% of the country's exports (IFPRI, 2023). However, Ethiopia's agricultural industry remains highly vulnerable to climate-related challenges, particularly recurrent droughts (Mekonnen et al., 2021).

In agricultural production, farmers use various inputs such as land, labor, seeds, water, fertilizers, and other technologies to cultivate specific products. Climate change significantly affects critical inputs, particularly land and water. For instance, rising temperatures and reduced rainfall contribute to the proliferation of diseases, pests, and worms, which in turn diminish agricultural productivity. Given that agriculture is one of the sectors most vulnerable to the risks and consequences of global climate change, and is inherently sensitive to weather conditions, climate variability exerts a direct influence on agricultural output (Chichongue *et al*., 2015). Ensuring food security for the world's rapidly growing population is increasingly challenging due to the adverse impacts of climate change on agriculture (Solomon *et al*., 2021).

Crop sensitivity to temperature and rainfall fluctuations has a direct impact on Ethiopian smallholder farmers and their livelihoods (Ketema & Negeso, 2020). Due to a lack of empirical research at the local level, Ethiopia is particularly vulnerable to the effects of climatic variability (Degife et al., 2021).

Previous research in Ethiopia has primarily examined the determinants of climate change adaptation strategies. Additionally, studies have explored perceptions, vulnerability, and adaptation using cross-sectional data from various regions, including the east, north, south, and central parts of Ethiopia (Seyum, 2015; Seid et al., 2016; Weldlul, 2016; Haftu et al., 2017; Befikadu et al., 2019).

Climate change research needs to be locally relevant in order for its findings to be used. Since agriculture in the east and west Wollega zones depends on rainfall, climate change, with low yearly rainfall during certain seasons and high rainfall during others, along with rising temperatures, negatively impacts local farmers' maize crop yields. Crop output has been declining in the study area due to soil acidity, crop diseases, land degradation, and a lack of climatic information and farmers are less likely to change their agricultural practices and adapt to climate change in order to reduce the negative impact of climate change.

In western Ethiopia, particularly in the East and West Wollega zones, maize serves as a crucial food and cash crop. Notably, there is a lack of local studies examining the perceptions and adaptation strategies of maize farmers in this region to climate change. The only relevant study conducted to date is by Chemeda *et al*. (2023), which investigates the factors influencing the perception of climate change and the adaptation strategies of coffee-based agroforestry farmers in western Ethiopia.

Existing literature often treats the perception and adaptation to climate change as separate phenomena, which limits the understanding of farmers' comprehensive responses to climate change. To address this gap, our study simultaneously examines both the perceptions and adaptation strategies of maize farmers and identifies the factors influencing each. By linking perception with adaptation, we aim to uncover common mediating factors.

This approach will provide valuable insights for policymakers, assisting in the design of targeted interventions to promote effective climate change adaptation among farmers in the study area and across Ethiopia, particularly in regions with similar socio-economic contexts. The primary objective of this study is to examine farmers' perceptions of climate change and their adaptation decisions, as well as to identify the factors influencing these perceptions and adaptation choices.

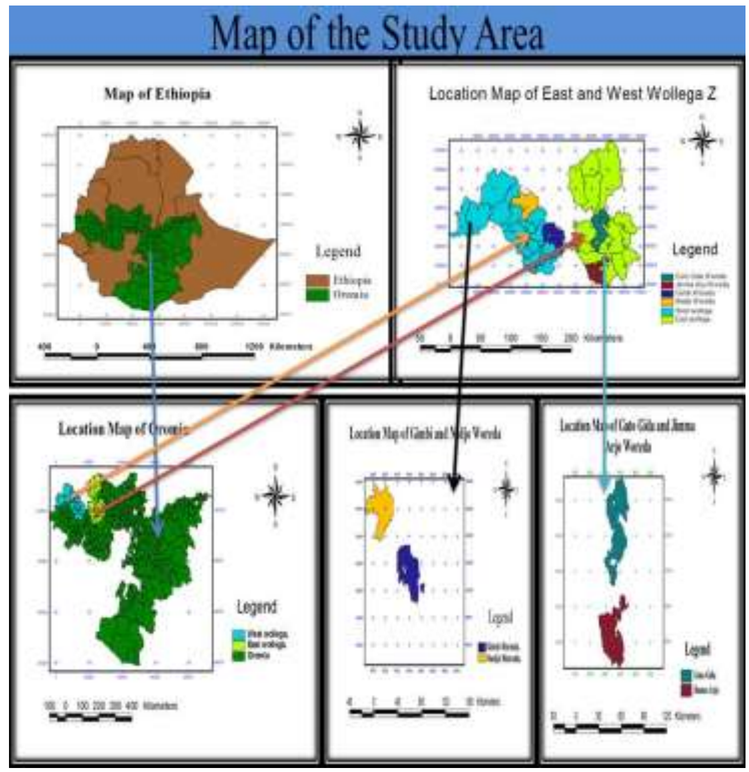
Methods

Description of the study area

The study was conducted in two zones of western Ethiopia namely East Wollega and West Wollega zones using four districts: Guto Gidda, Jimma Arjo, Ghimbi and Nedjo. The two zones constitute the primary maize-producing areas in Ethiopia. These two zones collectively contribute approximately 10% of the total maize cultivation area and account for 12% of the country's maize production (CSA, 2018).

Alongside maize, other major cereal crops grown in these zones include wheat, barley, teff, and sorghum. Notably, maize plays a pivotal role, contributing the highest share (33.7%) to the annual total cereal output, followed by teff (19.8%). Additionally, maize cultivation covers 23.4% of the total cereal area cultivated during the 2020/21 season (CSA, 2021), underscoring its significant importance in food crop production in the study area.

Figure 1: Map of the study area



Source: Own sketch from Ethio-GIS (2023).

Sampling Design and Sample Size

A cross-sectional descriptive study design was utilized in this research. Both primary and secondary statistical data were gathered for the analyses. The research implemented a multistage sampling method, random sampling (for the selection of sample zones and kebeles); purposive sampling (for choosing districts), and systematic random sampling (for identifying sample farm households or respondents). In the first phase, two zones, East Wollega, and West Wollega, were chosen from western Ethiopia. In the subsequent phase, two districts were selected from each zone (Guto Gidda, Jemma Arjo, Ghimbi, and Nedjo) based on the existence of national meteorological stations in the woreda.

Then, kebeles (the smallest administrative divisions in Ethiopia) were randomly chosen from each district in proportion to the number of kebeles within those districts. The sampling frames were developed using household head lists from the selected kebeles, with the sample size determined proportionally to the total number of households in each kebele. Subsequently, a systematic random sampling technique was employed to select household heads for the study.

Utilizing the formula established by Krejcie and Morgan (1970), the size of the sample was calculated with a 95% confidence interval, a chi-square statistic for a single degree of freedom, and an expected population proportion of 0.5 alongside a precision level of 0.04.

$$n = \frac{\chi^2 NP(1-P)}{d^2(N-1) + \chi^2 P(1-P)}$$

Where

n is the required sample, χ^2 is the tabulated chi-squared value for one degree of freedom at a 5% significance level (3.841), N denotes the total population of maize-producing farm households across the four woredas, P is the population proportion estimated at 0.5 as this would yield the largest sample size, and d indicates the accuracy level expressed as a proportion (0.05), which is a commonly accepted standard error. The required sample size (n) from the total 50,079 households (N) (which is the total of 13,216, 9,634, 13,114 and 14,115 households from Guto Gida, Jemma Arjo, Ghimbi, and Nedjo districts, respectively) was 588.

The sample size from each district was determined to be proportional to the respective population sizes; hence, the sample sizes were 154, 114, 153 and 167 from Guto Gida, Jemma Arjo, Ghimbi and Nedjo districts, respectively.

Data Sources and Collection Methods

The data required for the research was gathered from both original primary and secondary sources. Primary data were collected through household interviews employing a structured survey during the 2022/23 production season. The survey was pre-tested for accuracy and relevancy. To facilitate data gathering, the survey was translated into Afan Oromo.

Secondary data were obtained from numerous offices, including those in the eastern and western Wollega zones, as well as the Woreda agricultural office, the Central Statistical Agency (CSA), and the Ethiopian Meteorology Institute.

Methods of Data Analysis

The research used a combination of descriptive and econometrics techniques as described below. A Bivariate Probit (BVP) model was used to investigate the factors that affect farmers' perceptions and responses to climate change. For this analysis, STATA software version 15 was employed.

Descriptive method

Farmers' perception of climate change and their adaptations were assessed using descriptive statistics, including averages, frequencies, and percentages. Refer to Table 1 below for a detailed account of the variables in focus.

Econometric metho

The Bivariate Probit (BVP) model was utilized to identify the factors that affect farmers' perceptions and adaptation to climate change in western Ethiopia. The two primary variables of focus in this research are farmers' perception to climate change and adaptation decisions to it. Both variables are binary; the first indicates whether a farmer perceive climate change (1 = the household head has recognized the change, and 0 = otherwise), while the second reflects whether the farmer employs any adaptation strategies (1 = the household has adapted one or more strategies, and 0 = otherwise). In a standard probit model, there exists only one binary dependent variable Y, which corresponds to one latent variable Y* is used.

On the other hand, within the bivariate probit model, there are two binary dependent variables, Y1 and Y2, leading to the existence of two latent variables, Y1* and Y2*. It is supposed that each observed variable takes value of 1 if its underlying fundamental latent counterpart exceeds a threshold, and 0 otherwise. Consequently, the bivariate probit regression equation can be articulated as:

$$Y_{1i} \begin{cases} 1 \; if \; Y_{1i}^* > 0 \\ 0 \; otherwise \end{cases} \quad (1)$$

$$Y_{2i} = \begin{cases} 1 \; if \; Y_{2i}^* > 0 \\ 0 \; otherwise \end{cases} \quad (2)$$

where:

$$Y_{1i}^* = X_1\beta_1 + \varepsilon_1 \quad (3)$$

$$Y_{2i}^* = X_2\beta_{2i} + \varepsilon_2 \quad (4)$$

The variables Y_{1i} and Y_{2i} are mutually dependent or endogenous, Y_1 is binary coded perceived climate change, and Y_2 is binary coded adaptation to climate change. The X's are exogenous variables, and ε_1 and ε_2 are the stochastic disturbance terms.

Fitting the bivariate probit model involves estimating the values of β_1 and β_2. To do so, the likelihood function of the model is maximized as:

$$L(\beta_1\beta_2) = [\pi p(Y_1 = 1, Y_2 = 1 /\beta_1,\beta_2)^{Y_1,Y_2} p(Y_1 = 0, Y_2 = 1 /\beta_1,\beta_2)^{(1-Y_1)Y_2} p(Y_1 = 0, Y_2 = 0 /\beta_1,\beta_2)^{(1-Y_1)(1-Y_2)} p(Y_1 = 1, Y_2 = 0 /\beta_1\beta_2)^{Y_1(1-Y_2)}] \quad (5)$$

The parameters' coefficients must be adjusted for the bivariate probit model depending on the significance of ρ. If a Wald test indicates that rho is statistically significant, it suggests that both perception and adaptation to climate change are endogenous. Conversely, if rho is found to be statistically insignificant, there is no endogeneity bias, allowing both equations to be estimated independently as binary probit.

The dependent variables of the study were perception and adaptation to climate change which were expected to be affected by the independent variables like households' demographic, socioeconomic, and institutional factors.

Table 1: Variables definition and hypothesis

Explanatory variables	Expected sign	
	Perception	Adaptation
Sex of the head (1= Male)	+	+
Age of the head (Years)	+	+
Education level of the head (Grade completed)	+	+
Farming experience (Years)	+	+
Family size (Number)	+	+
Farm size (Ha)	+	+
Credit access (1=Yes)	+	+
Extension contact (Number/year)	+	+
Market distance (Km)	-	-
Farm income (ETB/year)	+	+
Off/non-farm income (ETB/year)	+/-	+/-
Access to information (1=Yes)	+	+
Agro-ecology (1=Highland/midland)	-	-
Fragmentation (Number of plots)	-	-

Source: Own Expectation

Results and Discussion

Descriptive Results

To assess the perception of farmers on climate change and their adaptation decisions, descriptive statistics were employed. As illustrated in Table 2, from the surveyed participants in midland and highland ecological zones, about 93% (337) perceived or believed that climate change was taking place in their area, while approximately 7% (27) did not acknowledge the presence of climate change.

Additionally, the findings reveal that about 97% (218) of participants in the lowlands perceived changes in the climate, with around 3% (6) not recognizing any climate change. This suggests that almost all respondents from the lowlands were convinced that local climate change was occurring. Overall, 94% (555) of the total respondents believed that the study area was experiencing climate change. The study findings demonstrate that farmers in the area have a strong awareness of climate change.

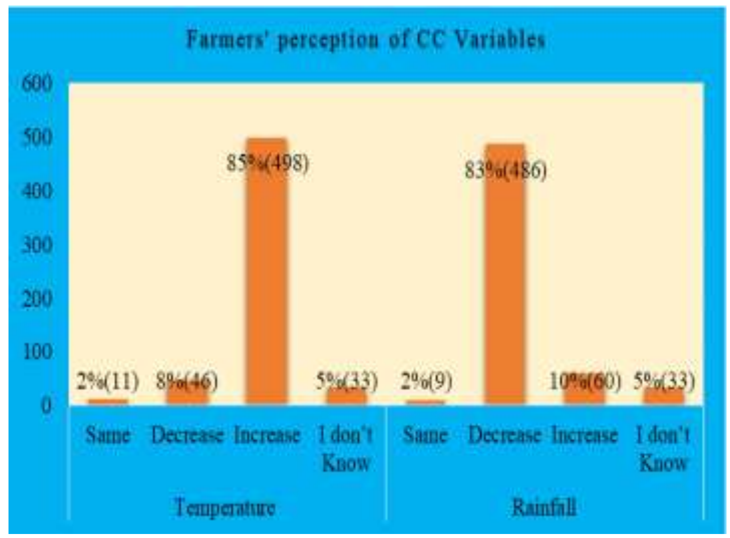
Table 2. Perception about climate change by agro-ecology

Agro ecology	Perception				Total
	Yes		No		
	No.	%	No.	%	
Midland and highland	337	93	27	7	364
Lowland	218	97	6	3	224
Total	555	94	33	6	588

Source: Computed from survey data (2023)

The survey results indicate that a majority of respondents 85% (498) perceived an increase in temperature over the last ten years in the study area, while only a few 8% (46) reported a decrease in temperature, and the remaining 5% (33) and 2% (11) reported as they don't know and same respectively Additionally, a large number of respondents 83% (486) perceived a decreasing in rainfall amount, while only a few 10% (60) stating an increasing in rainfall and the remaining 5% (33) and 2% (11) stated as they don't know and same respectively (Figure 2). In general, farmers in the study area perceive an increase in temperatures and a decrease in rainfall, which aligns with the findings of Tessema *et al*. (2013) and Belay *et al*. (2017).

Figure 2: Farmers' perception of change in annual rainfall and temperature



Source: Computed from survey data (2023)

Approximately 68% (248) of the respondents in midland and highland areas have adopted various adaptation strategies, while about 32% (116) did not. Similarly, about 68% (152) of respondents in lowland areas have adopted different strategies, with 32% (72) not taking any measures in response to climate change (Table 3).

Overall, 68% (400) of the sample households have implemented adaptation strategies, while 32% (188) have not (Table 3). The study results indicate that similar attention was given by the farmers to climate change adaptation across agro-ecologies.

Table 3: Adaptation to climate change across agro-ecology

Agro ecology	Adaptation				Total
	Yes		No		
	No.	%	No.	%	
Midland and highland	248	68.1	116	31.9	364
Lowland	152	67.9	72	32.1	224
Total	400	68.02	188	31.9	588

Source: Computed from survey data (2023)

The findings of the survey indicated that a significant number of farm households in the sample perceived fluctuations in rainfall and temperature over the long term, implementing diverse strategies to tackle climate change in the studied area. A majority of the respondents which accounts for about 72% (400) of the sample households not only perceive but also adapt at least one adaptation strategy against climate change, whereas 28% (155) recognized the changes without taking any adaptive measures. However, 100% (33) of the respondents neither perceived nor adapted to climate change due to a lack of awareness (Table 4). The study results indicate that households that did not perceive about occurrence of climate change did not take any adaptation strategy. This highlights the importance of farmers' perception in adopting various adaptation strategies to overcome the problem of climate change.

Table 4. Perception and adaptation to climate change

Perception	Adaptation				Total
	Yes		No		
	No.	%	No.	%	
Yes	400	72	155	28	555
No	0	0	33	100	33
Total	400	68	188	32	588

Source: Computed from survey data (2023)

Econometric Results

The bivariate probit model (BVP) was employed to analyze the determinants of farmers' perceptions and responses to climate change. This model assumes that there is no collinearity among the independent variables (Gujarati, 2004). To assess the presence of multicollinearity issues among the explanatory variables, the Variance Inflation Factor (VIF), was conducted as shown below.

$$VIF = \frac{1}{1 - {R_j}^2}$$

Where VIF is the variance inflation factor; R_j^2 is the adjusted square of the multiple correlation coefficients that result when one explanatory variable (j) is regressed against all others. Multicollinearity is a problem if there is a roughly linear relationship between the explanatory variables and at least one of the test regressors has a high R2 value. There was no multicollinearity problem among the explanatory variables in this study, as each variable's VIF result was less than 10.

Farmers' perception of climate change is essential for successful adaptation, as a farmer who does not perceive climate change cannot appropriately adapt to solve the adverse effect of climate on their crop production. To analyze the connections between perception, adaptation, and their influencing factors, a bivariate probit model was used. This model evaluated the two dependent variables (perception and adaptation) against explanatory variables connected to household characteristics, farming attributes, socioeconomic influences, and institutional factors. The null hypothesis stating that no correlation exists between the disturbance terms of perception and climate change adaptation is rejected at a 5% significance level, based on the findings from the maximum likelihood estimation of the bivariate probit model. This suggests that the bivariate probit model is appropriate for examining the relationship between farmers' perceptions and adaptation to climate change.

Correlation analysis showed that farmers' perception and adaptation to climate change are interdependent and positively related at the 1% significance level, indicating that perception is a primary factor in adapting to climate change stresses.

Farmers' perceptions regarding climate change and their corresponding adaptation decisions were shown to have a positive and significant relationship. The model accuracy predicts the regression, and the Wald Chi-squared test strongly rejects the hypothesis that there is a lack of explanatory power. For the variables' regression, the bivariate probit model fits the data quite well.

Table 5. Results of bivariate probit regression model of farmers' perception and adaptation to climate change.

Explanatory Variables	Dependent Variables							
	Adaptation to climate change				Perception of climate change			
	Coefficient	p-value	Marginal effect	p-value	Coefficient	p-value	Marginal effect	p-value
Sex	1.265***	0.000	0.473***	0.000	1.095***	0.000	0.462***	0.000
Age	-0.043	0.114	-0.015	0.114	0.063	0.235	-0.015	0.122
Education	0.069***	0.000	0.024***	0.000	0.117**	0.014	0.015***	0.004
Farming experience	0.044	0.119	0.015	0.119	-0.054	0.314	0.015	0.114
Family size	0.096***	0.002	0.033***	0.002	0.156***	0.006	0.024**	0.016
Farm size	0.103***	0.002	0.035***	0.002	0.129	0.209	0.035***	0.003
Credit	0.250	0.143	0.082	0.122	-0.585**	0.025	0.082	0.118
Extension contact	0.067	0.295	0.023	0.295	0.03	0.744	0.023	0.284
Market distance	0.139*	0.071	0.048*	0.070	0.726***	0.001	0.037*	0.064
On farm income	-9.23^{e-07}	0.220	-0.000	0.219	-1.29^{e-06}	0.484	-0.000	0.226
Off/non-farm income	7.41^{e-07}	0.284	0.000	0.283	0.00164	0.570	0.000	0.252
Access to information	0.211	0.701	0.073	0.700	5.342	1.000	0.073	0.680
Agro-ecology	0.097	0.514	0.034	0.516	-0.728**	0.023	-0.053**	0.017
Fragmentation	0.105*	0.094	0.036*	0.094	0.373***	0.009	0.028*	0.081
Constant	-1.34**	0.049			-2.735**	0.029		
Wald test of rho = 0: $Chi^2(1)$ = 38.320				Joint probability of success = 0.680				
Wald $Chi^2(28)$ = 184.700				Joint probability of failure = 0.263				
Log likelihood = -363.464				Observations = 588				

***, ** and * represents 1%, 5% and 10% level of significance, respectively Source: Model result estimated from survey data (2023)

Households are more likely to jointly perceive and respond to climate change, based on the joint probability of these processes for success or failure. The findings revealed that the likelihood of success for sample households in perceiving and responding to climate change was 68%, while the probability of failure is about 26.3%. This confirmed the rejection of the null hypothesis, which suggests that perception and adaptation decisions of climate change are independent.

The bivariate probit model result indicated that several explanatory variables significantly impacted farmers' perception and adaptation decision to climate change. The model's results revealed that sex, education level, household size, farm size, distance from market, Agro-ecology and land fragmentation influence farmers' perceptions of climate change; while sex, educational level, family size, farm size, distance from market, and land fragmentation were identified as key factors influencing adaptation decision of farmers to climate change.

At a 1% significance level, the perceptions of farmers and their adaptation decision to climate change are positively and significantly influenced by the sex of the household head. Male household heads increase by 46.2% and 47.3% higher likelihood of perception and adaptation decision to climate change, respectively. This indicates that male farmers tend to perceive and respond more effectively than their female counterparts. This trend reflects the longstanding association of agriculture with a largely male demographic. Male farmers frequently encounter greater exposure to climate-related challenges, enhancing their perception and adaptation capabilities. These results highlight the necessity of recognizing that climate-related problems are not free from gender bias, pointing to the urgent need to specifically engage women in enhancing their awareness and responsiveness to climate change (Obayelu et al., 2014).

Education significantly and positively influences farmers' perceptions of and responses to climate change at a 1% significance level. The results show that other variables being a constant one-year increase in educational level leads to an increase in the probability of perception by 1.5% and the probability of adaptation decision to climate change by 2.4%. This positive association implies that higher education levels enhance a farmer's ability to perceive and accurately predict climate change thereby deciding and adapting appropriate adaptation strategies to climate change.

These findings are consistent with previous studies by Debela et al. (2015) and Kabir et al. (2016), which also identified a positive and significant effect of education on climate change perception. Furthermore, empirical evidence from Barrucand et al. (2016) underscores the crucial role of education in addressing climate change, particularly within rural communities.

At significance levels of 5% and 1%, respectively, the study's findings indicate that family size has a significant and positive effect on farmers' perceptions and responses to climate change. The findings of the study show that other variables being constant for every additional family member in the household, the likelihood of farmers’ perception and adaptation decision to climate change increases by 2.4% and 3.3%, respectively. This suggests that larger household sizes contribute to better awareness and decision-making regarding climate change adaptation, likely due to the labor-intensive nature of adaptation strategies.

Furthermore, the model results specify that farm size positively and significantly affects both farmers’ perception and adaptation decision to climate change at a 1% significance level. Increasing farm size by 1 hectare leads to a 3.5% increase in the likelihood of farmers’ perception and adaptation to climate change other factors remain constant. The availability of surplus fertile land provides farmers better opportunities to implement effective adaptation strategies.

The proximity to the closest market place has a positive and statistically significant impact on both farmers’ awareness and response to climate change at a 10% significance level. Other variables being constant, for every additional walking hour spent to the nearest market, the probability of farmers’ awareness and response to climate change increases by 3.7% and 4.8%, respectively. This might be attributed to the fact that farmers in remote areas rely more heavily on agriculture compared to those situated closer to the market, and thus place greater importance on recognizing and adapting decisions to climate change.

Agro-ecology has a negative and statistically significant effect only on farmers’ perception at a 5% probability level. According to the model results, other variable being constant, the likelihood of farmers’ perception decreases by 5.3% as we move from lowland to midland and highland areas. This observation may be attributed to the fact that climate variability is particularly pronounced in lowland agro-ecology.

The findings of this study indicate that land fragmentation exerts a positive and statistically significant influence on farmers’ perception and adaptation to climate change, at a 10% significance level. Specifically, each additional farm plot increases the probability of farmers perceiving and adapting to climate change by 2.8% and 3.6%, respectively. These results suggest that farmers managing a greater number of farm plots demonstrate heightened awareness of climate change and are more proactive in implementing adaptive strategies compared to those with fewer farm plots.

CONCLUSION

This research faced limitations due to the limited sample size of the household survey, the few study regions, and the designated study durations. Nevertheless, in western Ethiopia, the traditional insight of farmers regarding their perception and adaptation decisions of farmers to climate change yielded hopeful outcomes.

The vast majority of farmers believed that their maize yield had been adversely impacted by climate change. The finding identified several factors that influenced farmers' perception and their adaptation decisions. These factors include land fragmentation, sex, educational background, household size, farm size, proximity to the nearest market place, and agro ecology. Agro ecology influenced only the farmers' perception, not their adaptation decision to climate change. The results suggest that to improve farmers’ perception, adaptation decision and enhance their resilience in reducing the effects of climate change on their maize production, it is essential to identify the factors that influence both perception and adaptation decisions at the local level.

To enhance farmers’ perception and adaptation to climate change, and increase agricultural production and productivity, policy measures such as improving farmer’s education; awareness creation for female household heads about climate change, and strengthening the capacity of farmers to adapt to climate change are necessary.

Acknowledgements
The authors extend their sincere gratitude to the sample respondents, the Central Statistics Agency, and the Ethiopian Meteorology Institute for their valuable time, cooperation, and provision of the data essential for this study.

Funding information
No specific grant was obtained for this study from any public, private, or nonprofit funding agency. However, with reference number W.U.SGS/259/2013 E.C., the Ethiopian Ministry of Education provided 45,000 ETB, or approximately 750 USD, in financial support, for which the authors are thankful.

Competing Interests Statement
The authors declare that they have no competing interests

Author Contributions
The study's design, data collection from various sources, data compilation, entry, and analysis, as well as result interpretation, editing, and manuscript preparation, were all conducted by W.S. The two authors, J.H. and H.H., were involved in supervision. They also contributed to shaping the manuscript, made valuable contributions, edited it, and offered feedback on how to make it better. All authors have thoroughly reviewed and provided their approval for the final published version of the manuscript.

Data Availability Statement
The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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