Farmer’s Perceived Impacts of Climate Change on Agricultural Production and Coping Strategies in Arsi Negelle Woreda, Ethiopia

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Abstract

This study examines trends in climate variability, smallholders' perceptions of changes in climate and its impacts on agricultural production; further it identifies the coping strategies implemented in the study area, Arsi Negelle Woreda. Data was collected through surveys with 131 households. In addition, annual average temperature and precipitation data from 1983 and 2016 were obtained from the National Meteorological Agency of Ethiopia. The study applied the Coefficient of Variation, Standard Rainfall Anomaly, a nonparametric Sen's slope estimator, and Mann–Kendall's trend tests to detect the magnitude and statistical significance of climate variability in the study area. The Multinomial regression models were used to analyze farmers' decisions to choose climate change coping strategies. The findings revealed that farmers recognize significant challenges like drought, crop failures, and pest outbreaks. Consequently, most farmers chose drought and disease-resistant short-season variety (75%), crop diversification (66%), and irrigation (47%) strategies to adapt to the changing climate. The regression model indicated that education, farmland size, sex of household head, access to credit, and market access and extension services were the key factors determining farmers' decisions to choose climate change coping practices. Thus, increasing their engagement in livelihood diversification is the best alternative way of coping mechanism. The study further concludes that area-specific coping strategies are crucial to reducing the adverse impact of climate change on agricultural production and food security.

Keywords: *Climate change, coping strategies, variability, drought, food security*

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1. Introduction

Climate change is one of the most critical challenges facing humanity in the 21st century, profoundly affecting environmental, social, and economic systems worldwide (Abbass et al., 2022; Dietz et al., 2024; Saleem et al., 2024). In sub-Saharan Africa, where agriculture forms the backbone of rural economies and provides livelihoods for the majority, climate change has a substantial impact on communities dependent on smallholder farming (IPCC, 2021; Morton, 2007). Climate-induced disruptions, including increasing temperatures, changing precipitation patterns, and more frequent extreme weather events such as droughts and floods threaten crop yields, water resources, and food security, intensifying vulnerabilities for millions across the region (Asfaw et al., 2018). According to Barros et al. (2014), a temperature increases over 1.5°C is likely to threaten crop yields, access to water resources, and food system stability globally, with acute risks in arid and semi-arid regions. To mitigate these risks, the Paris Agreement, a legally binding international treaty on climate change, was adopted in 2015 to limit the global temperature increase to below 1.5°C (Schleussner et al., 2016).

In Ethiopia, agriculture accounts for approximately 32% of the GDP and employs about 70% of the population, with smallholder farmers contributing the majority of the country's agricultural output (World Bank, 2020; Yigezu, 2021). However, Ethiopian agriculture is primarily rain-fed and thus highly susceptible to climate change(El Bilali et al., 2020; Likinaw et al., 2023; Mekonnen et al., 2021b). Recent studies show that rising temperatures and erratic rainfall have led to prolonged droughts, flooding, soil degradation, and increased prevalence of pests and diseases, all of which contribute to crop failure and livestock mortality (Asfaw et al., 2018; Gebrehiwot & van der Veen, 2021; Simane et al., 2016). According to the Ethiopian Panel on Climate Change (2015), the country has experienced a series of severe droughts over the past decades, with significant implications for agricultural productivity and food security. These climate-related risks significantly affect smallholder farmers, who have limited resources to adapt (Berhanu, Ayele, Dagnew, et al., 2024).

Adaptation to climate change has become essential for smallholder farmers to build resilience and sustain their livelihoods (Deressa et al., 2010; Simane et al., 2016). It refers to adjustments made within natural and human systems in response to actual or anticipated climate impacts, aiming to mitigate harm or harness potential benefits (IPCC, 2021). Adaptation practices vary widely, from traditional coping strategies like adjusting planting dates to more recent innovations, such as adopting drought-resistant crop varieties, implementing soil and water conservation techniques, and diversifying income sources (Belay et al., 2017; Ojo & Baiyegunhi, 2020).However, the capacity of farmers to adopt effective adaptation measures is often hindered by a range of socioeconomic and institutionalfactors such as limited access to education, credit, extension services, and markets (Deressa et al., 2010). In addition, limited water resources and inefficient irrigation practices further constrain agricultural productivity and hinder adaptation efforts among smallholder farmers(Ahmed & Ahmed, 2019).These issues are intensified by inadequate infrastructure and weak institutional support systems, which exacerbate farmers' vulnerability to climatic shocks(Mekonnen et al., 2021a). Smallholder farmers also face significant constraints in accessing financial resources and credit facilities, restricting their ability to invest in sustainable practices that could enhance their resilience to climate variability and change(Zerssa et al., 2021).

These climatic challenges are particularly pronounced in the Central Rift Valley of Ethiopia, specifically in Arsi Negelle Woreda. The area is characterized by erratic rainfall patterns, recurrent droughts, and rising temperatures, all of which severely impact rain-fed agriculture, the primary livelihood for the majority of the population(Belay, 2013; Belay et al., 2017; Berhanu, Ayele, Dagnew, et al., 2024) Thus, examining farmers' perceptions of climate change and factors determining their copingstrategiesis crucial to inform more targeted and context-specific strategies. Moreover, while substantial research exists on the impacts of climate change and adaptation practices at broader scales (e.g. Bedada et al., 2018; Belay, 2013; Belay et al., 2017; Chimdesa, 2016),there is a gap in addressing localized and context-specific coping strategies. Most studies focus on national or regional trends, while limited attention has been given to factors that influence smallholder farmers' decisions and practices in response to climate variability(Ademe et al., 2020; Getachew, 2018; Nasir et al., 2021; Niles & Mueller, 2016; Tofu & Mengistu, 2023; Wassie et al., 2022).

This study aims to fill the gap by analyzing climate change and variability trends in Arsi Negelle Woreda and assessing smallholder farmers' perceptions of its impacts on agricultural production. The study will also investigate coping strategies practiced in the area, and factors influencing farmers' coping choices to help understand local responses to climate variability and inform location-specific coping strategies. Therefore, the objectives of this study are to analyze trends in climate variability, assess smallholders' perceptions of changes in climate and its impacts on agricultural production, and identify the coping strategies implemented in response to climate change.

2. Materials and Methods

Description of the study area

This study was conducted in Arsi Negelle*woreda,* locatedinthe West Arsi Zone of the Oromia Region (Figure 1). The woreda is bordered by East Shoa Zone in the Northeast direction, with Shashemene *Woreda* in the South direction, and with Shalla Woreda in the Southwest direction. Arsi Negelle Woreda's capital, Negelle Town, is located 250 km south of the national capital city of Ethiopia, Addis Ababa. Geographically, it is located between 7°17′N and 7°66′N, and 38°43′E and 38°81′E. The projected population of the woreda is

408,870, comprising 201,364 males and 207,506 females in 2023 (Ethiopian Statistical Services (ESS), 2023).

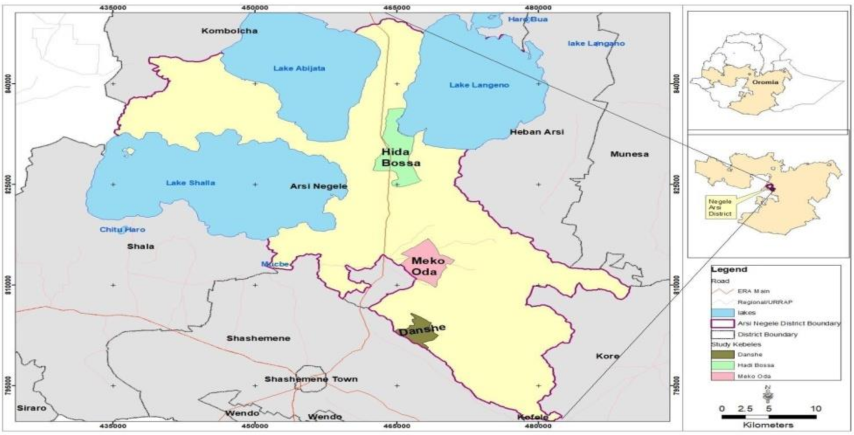

Figure 1: Map of the study area
Source: CSA, 2015, Ethio-GIS 2020

Arsi Negelle woreda is characterized by diverseagroecological zones, including highland, midland, and lowland areas. Each zone has unique climatic conditions, soil types, and vegetation, shaping the agricultural practices and land use patterns in the area.In addition, diversity in agroecological zones influences farmers' strategies to adapt to climatic shocks, such as selecting drought-resistant crops in the lowlands or intensive crop farming in the highlands (Gebremedhin et al., 2021). The woreda has a bimodal rainfall pattern, with the main rainy season during *Kiremt* season (June to September) and the small rainy season, *Belg* season (March to May). These rainfall patterns play a critical role in determining agricultural productivity, particularly in lowland areas that experience frequent droughts and water scarcity (Mekonnen et al., 2021; Mohammed et al., 2018; Tadesse et al., 2017).

The livelihoods of rural communities in Negelle Aris Woreda are heavily reliant on agriculture, which is highly susceptible to the impacts of climate variability and climate change. Agriculture here remains primarily rain-fed, making crop yields and food security vulnerable to erratic weather patterns, including droughts and unpredictable rainfall. Major crops grown in the area include maize, wheat, food barley, teff, haricot bean, potato, and other vegetables and fruits (Negelle Agriculture Office Report, 2011).

Maize, as a staple crop and a significant source of food security, occupies the largest share of cultivated land. However, maize productivity has been notably impacted by fluctuating rainfall patterns, which have become more severe due to climate change. Reduced rainfall and increased incidence of crop diseases have constrained maize yields (Abera et al., 2018).In addition to maize, the productivity of other key crops, such as wheat and teff, has similarly been influenced by changing climatic conditions, further exacerbating the food security problem in the woreda (Kassaye et al., 2021).

Research design and approach

This study employed a retrospective cross-sectional study design and mixed-methods approach, integrating both quantitative and qualitative data. A mixed approach was employed to provide a comprehensive understanding of farmer perceptions, coping practices, and the factors shaping climate coping strategies in Arsi Negelle Woreda. A retrospective cross-sectional study design was selected to examine correlations between long-term climatic trends and observed agricultural impacts, along with farmers' adaptive responses.

Sampling techniques and sample size

A two-stage sampling technique was applied to select the study households. In the first stage, 34 rural kebeles in the woreda were stratified based on their agroecological zones (highland, midland, and lowland), and three representative *kebeles,* one from each zone, were randomly selected. This is because farmers residing in different agroecology may face different or similar underlying causes of vulnerability to climate change in achieving food security for their households. In the second stage, sample households from each stratum were selected using systematic random sampling from the list of households living in the study *kebeles* and villages. Finally, using Kothari (2004), 131 farmers were selected for household surveys.

Data collection techniques

Both quantitative and qualitative data were collected for this study. Quantitative data were primarily collected through structured household surveys, while qualitative data were collected through focus group discussions, key informant interviews, and field observations. Qualitative data were collected for an in-depth understanding of local coping practices and community-level challenges. Field observations were also conducted to corroborate the data obtained through interviews and surveys. Additionally, 34 years of meteorological data were analyzed to assess long-term changes in climatic variables in the study area. We then triangulated smallholders' perceived changes in climate and variability with the analyzed meteorological data. This triangulation helped verify whether these changes are indeed occurring and provided a more reliable basis for understanding actual climate trends. Secondary sources were collected by reviewing published and unpublished literature such as books, journals, articles, reports, and e-resources.

Data Analyses techniques

Quantitative data were analyzed using descriptive and inferential statistics using STATA version 15. Descriptive analysis provided summary statistics on household demographics, climate perceptions, and coping practices. Inferential analyses were conducted using multinomial logistic regression to identify significant determinants influencing farmers' coping choices. This approach has been applied in similar coping studies in developing countries (Bryan et al., 2009; Deressa et al., 2010).

Climate data analysis involved trend and variability assessments using Coefficient of Variation (CV) and Standardized Precipitation Anomaly (SPA) to examine rainfall and temperature patterns over time. Trend analyses used the Mann-Kendall test and Sen's slope estimator to detect statistical significance in climate patterns, following methods established by Hu et al. (2020). The results were visualized through time series plots for ease of interpretation.

CV was calculated to evaluate the variability of rainfall and temperature. A higher value of CV is the indicator of larger variability, and vice versa. CV can be calculated as:

$$CV= \frac{\sigma}{\mu} * 100$$

Where CV is the coefficient of variation; σ is the standard deviation and μ is the mean precipitation.

According to Asfaw A. et al. (2018) CV is used to classify the degree of variability of rainfall events as less than 20 is less variable, CV between 20 and 30 is moderately variable, and CV greater than 30 is highly variable.

Standard Rainfall Anomaly (SRA) was calculated as:

$$SRA = Pt – Pm/\sigma$$

Where Pt is annual (rainfall) in year t, Pm is the long-term mean annual (rainfall) throughout observation and σ is the standard deviation of rainfall. The model differentiated drought severity into four scales: extreme drought (SRA < -1.65), severe drought (-1.28 > S > -1.65), moderate drought (-0.84 > S > -1.28), mild drought (0.0 > S > -0.84), normal (0.84 > SRA > 0.0), moderately wet (1.28 > SRA > 0.84), very wet (1.65 > SRA > 1.28) and extremely wet (SRA > 1.65) (Asfaw et al., 2018; Getachew, 2018).

Mann-Kendall (MK) was used to detect the trend of rainfall and temperature with Sen's slope estimator (test Pettitt's test was used to test the degree of homogeneity of the data. Trend analysis has been carried out on an annual basis, as well as for Belg and Kiremt seasons. The Mann-Kendall test as described by Hu et al. (2020) was used to detect trends. The significance level of the slope was estimated using Sen's method, which computes both the slope (the linear rate of change) and intercepts.

3. Results and discussion

Socioeconomic and demographic characteristics of respondents

Table 1 presents the demographic and socio-economic results of the study households. The majority of respondents (51%) fall within the 20–40 age range, followed by 36% aged 41–60, and 13% over 60 years old, with an average age of 47 years. This distribution suggests that around 87% of respondents are within the active working-age range and have relatively long years of farming experience to perceive environmental changes. Likewise, about 93% of the respondents are married with smaller percentages of widowed (3.82%), single (2.29%), and divorced individuals (0.76%). In terms of education, 46% of the respondents are illiterate, while 54% have completed formal or informal education.

The average family size of the surveyed household was 7.2 which is greater than the national average (5) with a minimum of 2 and 13 members, respectively. In addition, the result shows that the surveyed households have an average annual income of 40,709 ETB and an average landholding size of 1.8 hectares. These results highlight that while the area has large family labor and land resources, the relatively low income may limit investment in adaptive agricultural practices.

Table 1: Respondents socio-economic and demographic characteristics

Description	Category	M	F	Total	Percent
Age	20-40	56	11	67	51.15
	41-60	38	9	47	35.87
	Above 60	15	2	17	12.98
Educational status	Illiterate	45	15	60	45.8
	1-8	45	5	50	38.2
	9-12	16	2	18	13.7
	Diploma and above	3	0	3	2.3
Marital status	Married	105	17	122	93.13
	Single	3	0	3	2.29
	Divorce	0	1	1	0.76
	Widow	1	4	5	3.82
Average family size			7.2		
Average annual household income (ETB)			40,709		
Average landholding size (hectare)			1.8		

Source: Surveys, 2020

Trends in temperature and rainfall variability over 34 years (1983-2016)

Trends of rainfall

The results show that the mean annual rainfall of the study area during the study period was 649 mm, with 115 mm standard deviation and 17.7 CV (Table 2). *Kiremt* is the major rainy season in the study area, which contributes about 62.3% of the total rainfall. The short rainy season, which lasts from March to May (*Belg*) also contributes a substantial amount of rainfall, 27% of the total. The study revealed that the mean Kiremt rainfall (June– September) in the study area from 1983 to 2016 was 404.4 mm and 178.5 mm for the *Belg* season. Though the declining trends of *Belg* and annual rainfall are not statistically significant, the coefficient of variation (CV) was 21.06% for *Kiremt* and 44.8% for the *Belg* season, which implies higher rainfall variability during the *Belg* season than *Kiremt*. The high variability in rainfall, particularly during the *Belg* season, poses challenges for crop scheduling and necessitates. This variability poses challenges for crop scheduling, exacerbates drought conditions, and affects water availability, implying the urgent need for adaptive strategies to mitigate drought impacts (Mekonnen et al., 2021b).

The amount of annual rainfall had decreased by 28.3 mm over 34 years, 8.3 mm per decade, and 0.83 mm per year, affecting planting schedules and water availability. For the *Belg*, season rainfall had decreased by 23.8 mm per 34 years, 7 mm per decade, and 0.7 mm per year. However, *Kiremt* rainfall had increased by 10.2 mm in 34 years, 3 mm per decade, and 0.3 mm per year.

The result of SRA revealed that drought has occurred at different levels of severity in the study period during the annual *Kiremt* and *Belg* seasons. For instance, 2015, 2011, and 2009 were the driest years based on annual calculations. The droughts that occurred in 2015, 2011, and 2009 were so extreme that the SRA values were -1.91, -1.67, and -1.72, respectively (Figure 2). But 1996 and 2010 were the wettest years with anomaly values of 1.96 and 1.63, respectively.

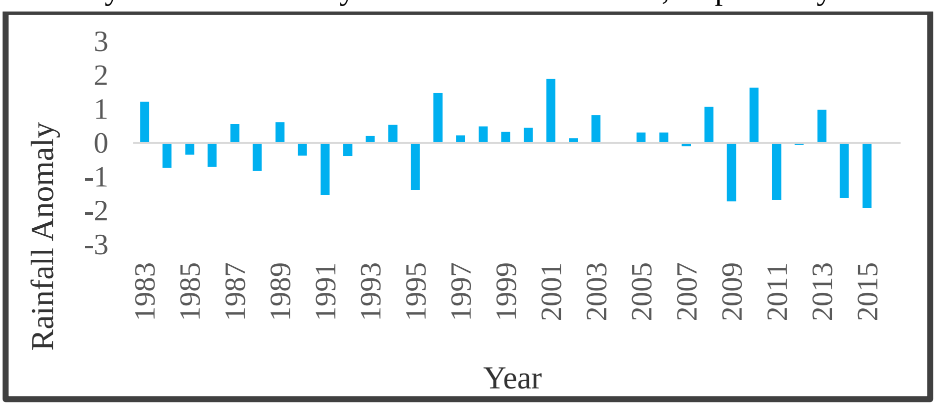

Figure 2 Rainfall anomaly of Arsi Negelle (1983-2016)
Source: Computed based on NMSA data, 2020

The wettest *Kiremt* season was in 1994 (1.79), 2008 (1.8), and 2012 (1.9), whereas the wettest *Belg* season was in 1987 (2.75), 2001 (1.76), and 2016 (2) (Figure 3). The result agrees with the findings of previous studies by Viste et al. (2013) and Alemayehu and Bewket (2017).

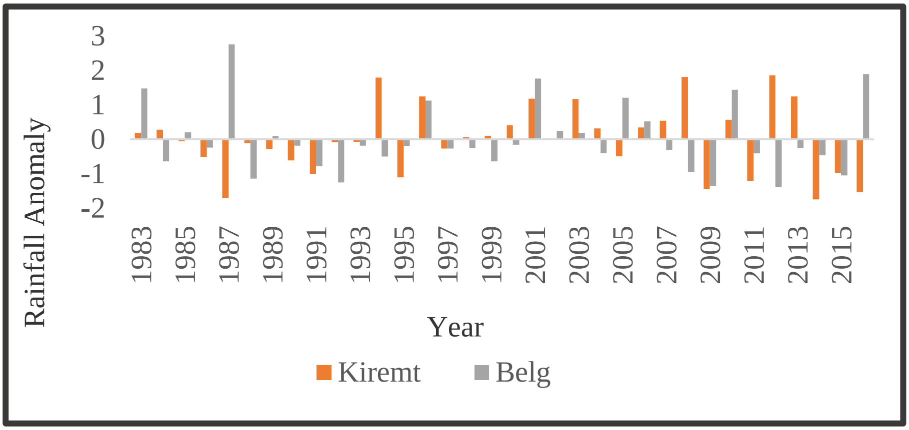

Figure 3: Rainfall anomalies of Belg and summer for Arsi Negelle Woreda

Source: Computed based on NMSA data, 2020

Trends of Temperature

The long-term annual mean temperature in the study area is 18.90C with 0.6 standard deviations and 3% CV. The long-term annual mean minimum and maximum temperatures of the Kiremt season are 12.90C and 24.50C with 6% and 2.3 % CV, respectively. For the Belg, the minimum temperature is 12.80C with 0.9 SD and 7.2% CV, and the maximum temperature is 27.40C with 07. SD and 2.7% CV.

The result indicated that CV in the Belg season is higher than that of Kiremt and annual temperature which implies more inter-annual variability of Belg temperature than Kiremt and annual temperature. The findings of this study agree with the previous studies by Kobe (2023) and Tadesse and Ahmed (2023) that reported 2009, 2011 and 2015 were the driest years in most parts of Ethiopia including the study area. According to Asfaw et al. (2018)and Haile et al. (2020), these drought years were either coinciding or shortly following El Nino events.

The trends of annual minimum, maximum, and mean temperature and Mann-Kendall test results for Negele Arsi station are presented in Table 2. The annual maximum mean temperature has been increased by 0.68^{0}c over 34 years, 0.25^{0}c per decade, and 0.02^{0}c per year. The annual minimum mean temperature has increased by 2.5^{0}c, 0.7^{0}c per decade, and 0.07^{0}c per year. Furthermore, the annual average temperature has increased by 1.56^{0}c per 34 years, 0.156 ^{0}c per decade, and 0.04^{0}c per year from 1983-2016. The result revealed that the trends of minimum, maximum, and mean temperatures of Negele Arsi have been increasing significantly from 1983 to 2016. Rising temperatures further complicate agricultural productivity by intensifying heat stress on crops and livestock. Similar studies have also revealed that rising temperatures and irregular rainfall patterns increasingly affect crop yields and livestock productivity (Gebrechorkos et al., 2019; Gebrehiwot & van der Veen, 2021).

Table 2: Trends of annual minimum, maximum, and mean temperature for Arsi Negelle

	Annual		Kiremt		Belg	
Temp	ZMK	Sen's Slope	ZMK	Sen's Slope	ZMK	Sen's Slope
MAX	2.85**	0.02	2.3*	0.02	2.3*	0.03
MIN	5.23***	0.08	4.2**	0.06	3.8***	0.07
AVE	5.16***	0.05	4.3***	0.04	4.1***	0.04

Note: *, **, *** statistically significant at 0.05, 0.01, and 0.001 alpha levels, respectively.

Source: Computed based on NMSA data, 2020

Farmers' perception of climate change and variability

Farmers' perception of rainfall variability and trends

Consistent with the observed climatic trends, the majority of study farmers perceived the declining trend of rainfall from time to time in their localities. About 74% of the respondents perceived that rainfall was declining, while only 11.5% of them perceived increasing trends in rainfall (Table 3). In addition, most farmers well realized the late onset and early cessation of rainfall becoming a major challenge with increased intensity and decreased trends of rainfall amount, and the number of untimely excess rainy days on the other side in the study area. For instance, about 94% and 90.8% of respondents confirm unpredictable onset and cessation of rainfall, respectively. From these results, we can conclude that the majority of farmers in the study area perceived a decrease in the level of rainfall.

Table 3: Farmers' perception of rainfall variability and trend

Perception of Rainfall Variability Indicators	No of respondents (N=131)			
	Yes		No	
	N	*%*	*N*	*%*
Rainfall amount decreases	116	88.5	15	11.5
Increase in rainfall amount	97	74.0	34	26.0
Decrease in rainy days	105	80.2	26	19.8
Increased rainfall intensity	122	93.0	9	7.0
The onset of rainfall becomes more unpredictable	123	94.0	8	6.0
The cessation of rainfall becomes more unpredictable	119	90.8	12	9.2
Drought occurrence frequency increase	120	91.6	11	8.4
Flood after rain	125	95.4	6	4.6

Source: Surveys, 2020

The information obtained from FGDs, and key informants confirmed that the main rainy season and *Belg* season rain are starting later and ending earlier. As stated by participants, farmers perceived that they had lost *Belg* rains, and it directly aligned with meteorological data which indicate a declining trend of *Belg* and annual rainfall in the Negele Arsi area for the period 1983-2016.

Farmers' perception of temperature variability and trends

The result shows that the majority of farmers (91.6%) perceived the increasing trend of temperature, while 8.4% did not (Table 4). An increase in temperature is among the manifestations of climate change. These findings are consistent with national and regional patterns, where increasing temperatures have been reported across Ethiopia (Asfaw et al., 2018; Haile et al., 2020). About 49.6% and 84.7% of farmers perceived an increase in hot days and warm nights, respectively, from time to time in their localities. The perception of farmers on the increasing temperature matches with the meteorological records of temperature trends presented in section 4.2. When perceptions are compared to the meteorological records of temperature data of Negele Arsi, both sources confirm an increasing trend in annual mean, maximum, and minimum temperature. Similarly, the information obtained from FGDs, and Key informant interviews revealed the increasing trend of temperature, hot days, and warm nights in their localities. In addition, farmers' perceptionsare consistent with scientific claims about the increasing trend of temperature in Ethiopia (Asfaw et al., 2018; Getachew, 2018; Jury & Funk, 2013; Tofu & Mengistu, 2023; Wassie et al., 2022).

Table 4: Farmers' perceptions of temperature variability indicators

Perception of Temperature Variability Indicators	No of respondents (N=131)			
	Yes		No	
	N	*%*	*N*	*%*
Temperature increases	120	91.6	11	8.4
Decrease in temperature	12	9.2	119	90.8
The number of hot days increases	65	49.6	66	50.4

The number of warm nights increased	111	84.7	20	15.3
No change in temperature	23	17.6	118	82.4

Source: Surveys, 2020

Perceived impacts of climate change on agricultural production

Farmers were asked to identify the impacts of climate variability and change on their agricultural production. The findings indicate that about 86% of respondents perceived the occurrence of frequent drought as a major impact associated with climate change (Figure 4). Drought affects agricultural productivity and disrupts water availability for crops and livestock. Moreover, about 71% of respondents perceived the occurrence of pests and diseases as the impacts of climate change affecting crops and livestock production. Empirical evidence also shows that rising temperatures and changing precipitation patterns create favorable conditions for pests and diseases, which can lead to increased infestations and reduced crop yields (Ademe et al., 2020; Niles & Mueller, 2016).

Furthermore, about 60% of respondents witnessed crop failure due to climate change and variability in the study area. Crop failure is often caused by erratic rainfall, extreme temperatures, and the compounded effects of pests and diseases, which together disrupt crop growth cycles (Challinor et al., 2015, 2018). This finding is consistent with studies showing that climate variability and extremes are increasingly leading to unpredictable harvests, especially in regions dependent on single-growing seasons (Schlenker & Lobell, 2010).

Fodder shortage, reported by 52% of respondents, highlights the indirect effects of climate change on livestock production. Literature suggests that forage and grazing lands are highly vulnerable to climate variability, particularly drought and seasonal shifts (Thornton et al., 2009). Reduced fodder supply leads to poor livestock feed, affecting productivity and income for farming households reliant on livestock (Nardone et al., 2010). About 31% of the study households perceived livestock death as a problem induced by climate change and variability (Figure 4). Heat stress, water scarcity, and inadequate fodder due to changing climatic conditions reduce livestock productivity and increase mortality rates (Nardone et al., 2010).

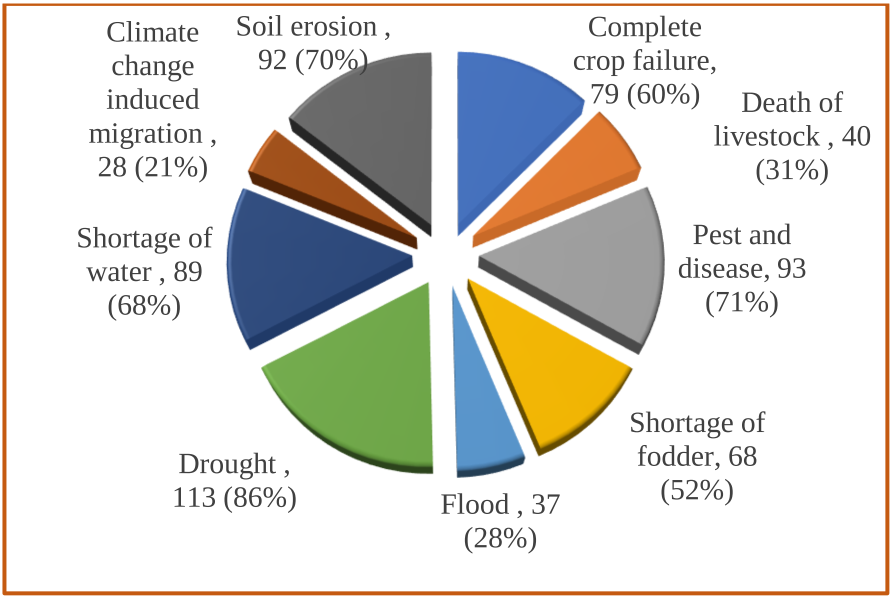

Figure 4: Perceived impact of climate change in the study area
Source: Surveys, 2020

Farmers' coping strategies to climate change and variability

Figure 5 illustrates the coping strategies practiced by farmers in the study area. The results show that 29% of the study respondents used drought-resistant crop and livestock varieties to adapt to climate change and variability. The results suggest that drought-resilient varieties are perceived as a reliable response to increasingly variable and unpredictable rainfall patterns. According to studies by Yisehak et al. (2021) and Kassie et al. (2015), drought-resistant crops have been widely adopted across semi-arid regions because they offer a direct, tangible benefit in enhancing yield stability under water-stressed conditions. This strategy reflects the shift towards climate-smart agriculture, which emphasizes resilience to environmental stressors.

Changing planting dates is the second most frequently used strategy among the study farmers (24%). This practice is especially relevant in areas experiencing shifting rainfall patterns due to climate change. A study by Deressa et al. (2010) and Berhanu, Ayele, Dagnew, et al. (2024) found that adjusting planting dates can significantly reduce risks associated with late-season droughts and frost, thus enhancing crop yields and farmer resilience.

The results indicate that 18% of the farmers in the study use crop diversification as a coping strategy. This means that by growing multiple types of crops, farmers can decrease their reliance on a single crop, which helps reduce the effects of crop-specific pests, diseases, and climate-related risks. Studies by Ngure et al. (2020) highlight how crop diversification can improve food security and income stability, making it a cornerstone of sustainable farming in regions vulnerable to climate variability.

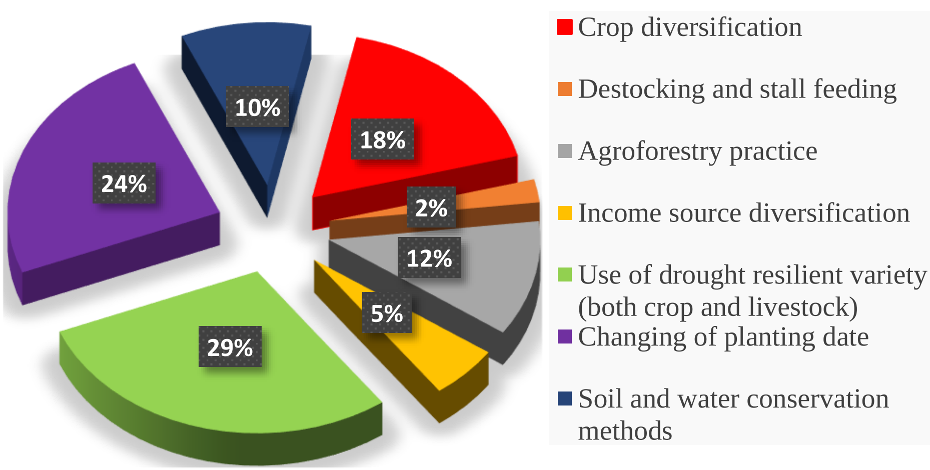

Figure 5: Coping strategies implemented by smallholder farmers in the study area
Source: Surveys, 2020

Determinants of Farmers of Coping Strategies to Climate Change

Multinomial logistic regression analysis was estimated to determine factors influencing household coping strategies to reduce the adverse effects of climate change (Table 5). Among the nine independent variables considered in the multinomial logistic regression model, six variables including sex, education, farm size, access to credit, access to market, and extension services were found statistically significant. The results of this study reveal that male-headed households were 55% more likely to adapt to crop diversification than female-headed households. This is because male-headed households often have more access to labor, resources, and decision-making power, which facilitates the adoption of labor-intensive strategies like crop diversification (Tazeze et al., 2012). Moreover, the result of this study indicates that female-headed households are better at practicing diverse sources of income like participation in petty trading and the sale of beverages. In line with this, some studies reported that women engaged in diversified income-generating activities will be able to enhance household food security and resilience (Asfaw et al., 2018).

As presented in Table 5, the education status of the head of the household improves the probability of adopting crop diversification, use of drought and disease-resilient variety (both crop and livestock), and soil and water conservation. The result showed a statistically significant positive association between education and the use of drought-resilient crops and livestock variety (coefficient = 1.34, $P < 0.030$). This is because educated farmers are generally better informed about climate risks and available adaptive options. Similarly, Deressa et al. (2010), Deressa et al. (2011) and Tazeze et al. (2012) revealed that education enhances farmers' understanding of climate change risks and equips them with the knowledge needed to adopt effective coping strategies.

The result of this study revealed that households with relatively large farmland are more likely to adapt to agroforestry practices (coefficient

= 1.3, $P < 0.002$) than those farmers with small land holdings (Table 5). Large farm plot size provides the opportunity to plant different fodder trees and integrate crops with livestock production. Similarly, Belay et al. (2017) showed that farm size has a positive and significant relationship with various climate change coping strategies.

The result shows that farmers with better market access could diversify their income sources more than farmers who have poor access to the market. The result is in line with Gebrehiwot & van der Veen (2021), who stated market access is an important determinant for the coping method hence it serves as a means of income source diversification as well as exchanging of information. Some studies have also highlighted that proximity to markets improves farmers' ability to diversify and increase income stability, which is a key aspect of climate resilience (Asfaw et al., 2018; Berhanu et al., 2024; Hussein, 2024).

Similarly, the study reveals that access to credit was positively associated with the adoption of drought-resistant crop and livestock varieties (coefficient = 2.31, $P < 0.002$) (Table 5), and adjusting planting schedules. Credit enables farmers to purchase inputs such as drought-resistant seeds and supports the flexibility needed to change planting schedules. This result is in line with the findings of Deressa et al., (2010); Deressa et al., (2011); Tazeze et al., (2012), who identified credit access as a crucial resource for adopting climate coping practices.

Access to extension services has a positive impact on creating awareness and dissemination of technologies for climate change coping and its adverse effects. Likewise, this study shows that access to extension service has a positive and significant impact on using drought-resilient crop and livestock varieties (coefficient = 1.5, $P < 0.01$) (Table 5). Extension services play a critical role in disseminating climate information and fostering the adoption of climate-smart practices (Alemayehu et al., 2024; Tilahun et al., 2023; Yami et al., 2024).

Table 5: Results of the multinomial logit on climate change copingchoice model

Explanatory variable	Crop diversification		Destocking and stall feeding		Agroforestry		Income source diversification		Drought resistance variety		Changing planting data		Soil and water conservation	
	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value
Sex	.055*	.050	-.319	.442	-.029	.391	-.080*	.050	-.009	.723	-.034	.306	-.001	.980
Age	-1.022	.172	-4.847	.100	.100	.898	-.699	.391	-.333	.640	.337	.709	-1.283	.118
Education	3.05***	.000	1.201	.695	-.341	.641	-.573	.505	1.34*	.030	1.307	.127	1.9*	.045
HH Size	.070	.526	.725	.239	-.016	.899	.044	.790	-.006	.958	-.064	.711	.027	.861
Farm size	.088	.811	-1.972	.338	1.3**	.002	.299	.503	.083	.806	.005	.991	-.008	.986
Farm Income	.000	.062	.000	.445	.000	.430	.000	.700	.000	.575	.000	.496	.000	.317
Market access	-.388	.506	-1.539	.428	-.713	.280	2.3*	.030	-1.091	.059	-.235	.781	.861	.254
Credit access	.275	.672	-17.265	.997	.080	.910	.814	.333	1.6**	.002	2.31**	.002	.881	.293
Extension service	-.251	.720	-3.048	.405	.890	.246	-.490	.602	1.5**	.010	20.319	.996	-1.267	.166
Constant	-4.833	.003	9.071	.522	-2.707	.107	-.246	.913	-1.470	.291	-20.355	.996	-2.323	.231

*Notes: *, **, *** = significant at 1%, 5%, and 10% probability level, respectively*

Source: Surveys, 2020

4. Conclusions and Recommendations

This study investigated trends in climate variability, assessed smallholders' perceptions of changes in climate and its impacts on agricultural production, and identified coping strategies implemented in response to climate change in Arsi Negelle Woreda. The findings revealed that the majority of respondents perceived a decrease in rainfall and an increase in temperature, aligning with observed climate data. The observed climatic changes lead to reduced agricultural productivity, water scarcity, and increased crop failures, collectively undermining food security. Farmers perceive these changes and are adapting through strategies such as crop diversification, the use of drought-resistant varieties, and adjusting planting dates.

The multinomial logistic regression results revealed farmers with larger landholdings were more likely to practice agroforestry, which integrates crop and livestock systems to enhance resilience to climate variability. Educated farmers showed a higher likelihood of adopting advanced strategies such as soil and water conservation, highlighting the role of education in coping with climate change. Market access and credit availability were also key factors influencing coping strategies. Farmers with better market access tended to diversify their income sources, making them less vulnerable to climatic shocks. Similarly, access to credit enabled households to invest in drought-resistant crops and modify planting schedules, implying the importance of financial support for adaptive capacity.

Finally, although the study provides valuable insights, it focused on a single woreda, limiting generalizability. Future research could expand to include diverse agroecological zones to capture a broader range of coping practices. Additionally, longitudinal studies on coping outcomes would be beneficial in assessing the long-term sustainability of strategies under ongoing climate change and variability.

Acknowledgment

We acknowledge all institutions and individuals for providing the necessary data and information to finalize the work. Above all, we are grateful to the farmers who participated in the study.

Conflicts of Interest: The authors declare no conflict of interest that could have appeared to influence the work reported in this paper.

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