



Farmers' adaptation strategies to climate change and its determinants: the case of Hulla district, Southern Ethiopia

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Abstract

The purpose of this study was to investigate smallholder farmers' perceptions of climate change, adaptation strategies used to offset climate change's negative effects, and factors that influence their adaptation decisions. The respondents' survey, focus group discussion, and key informant interviews were used to gather data. Descriptive statistics and a multinomial logit model were used to examine the data. The findings indicated that smallholder farmers perceive climate change in their area. According to the findings, smallholder farmers are most likely to use adaptation measures such as crop diversification, enhanced crop variety, soil and water conservation, and altering sowing dates. The multinomial logistic regression (MNL) analysis indicated that the limitations of extension services, a lack of climate change information, a lack of financial resources, and a lack of farm experience are the key factors that influence farmers' decisions to adopt adaptation strategies. As a result, having access to extension and disseminating information regarding agricultural practices with available finance sources is a viable approach to enhance farmers' decisions to adopt strategies to reduce the impact of climate change.

Keywords Adaptation strategies · Climate change · Perception · Smallholder farmers

Introduction

Climate change is currently emerging as a major environmental and development challenge of the twenty-first century. Scientific evidence indicates that due to the increased concentration of greenhouse gases in the atmosphere, the climate of the Earth is changing (IPCC 2013). Despite the global coverage of its impacts, there is variation in climate change manifestations based on location. In Africa, where the adaptive capacity of nations for climate change is constrained by several factors such as poverty, corruption, and institutional weakness, the impact is likely to increase (Barros et al. 2014). The study conducted by Challinor et al. (2014) projected that the cereal crop yield in Sub-Saharan

Africa (SSA) will be reduced in the range of 30–50% by 2050 when climate change increases as business as usual, with smallholders being the most affected.

Ethiopia, like other Sub-Saharan African countries, has been affected by climate change (Mahoo et al. 2013). The climate in the country is highly variable and difficult to forecast (Mengistu and Haji 2015; NMSA 2007; Evangelista et al. 2013). Furthermore, according to EPCC (2015), Ethiopia's geographic location and topography, together with the people's and resources' low adaptive capacity, lead to a high degree of sensitivity to climate change's adverse effects. Rainfall in Ethiopia can be delayed for several weeks or completely absent during the critical growing season, resulting in short- and long-term droughts with crop failures, which contribute to crop disease spread, food shortages, and famines (Evangelista et al. 2013). Droughts in Ethiopia over the last 50 years have caused human and livestock suffering due to shortages of water and grazing lands (Mahoo et al. 2013). In addition, a study by Evans et al. (2012) projected that by 2025, climate change will reduce GDP by 3–10%.

Studies on the effects of climate change, adaptation techniques, and their drivers have been conducted in several areas of the lowlands of the country (Regassa 2011; Awwaris 2012; Gebresenbet and Kefale 2012; Kassahun

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2013; Tafesse et al. 2013; Tsegaye 2014; Debela et al. 2015; Berhanu and Beyene 2015; Mengstu and Haji, 2015). None of them, however, has focused on the highlands of Ethiopia's southern region, including study area, though micro-level evidence is important for introducing site-specific adaptation strategies to reduce the impact of climate change. Consequently, farmers' perceptions of climate change and variability, and their adaptation strategies and determinant factors, have not been adequately assessed in the study area. Therefore, the current study was carried out to examine farmers' views of climate change and identify adaptation strategies and the determinants of adaptation strategies in order to minimize the negative effects of climate change.

Methodology

Study Area

The research was carried out in the Hulla district of southern Ethiopia, which is located at 06°26'30"N to 06°36'0"N and 38°28'0"E to 38°42'0"E (Fig. 1). The altitude of the district ranges from 2001 to 3000 m.a.s.l., and it is situated about 95 km to the south of Hawasa city and 370 km from the capital city of the country, Addis Ababa. The total population of the district is estimated to be 153,234 with an average density of 580 km² (CSA 2007). The Hulla district receives an average annual rainfall of 900.6mm. The long rainy season (Kirmet) occurs from June to October, and the short rainy season (Belg) lasts from mid-January to late May. The average yearly minimum and maximum temperatures are 12.4 °C and 24.5 °C, respectively (Hulla District Office Early Warning, 2020). The livelihood of the local people is mainly dependent on mixed crop-livestock production,

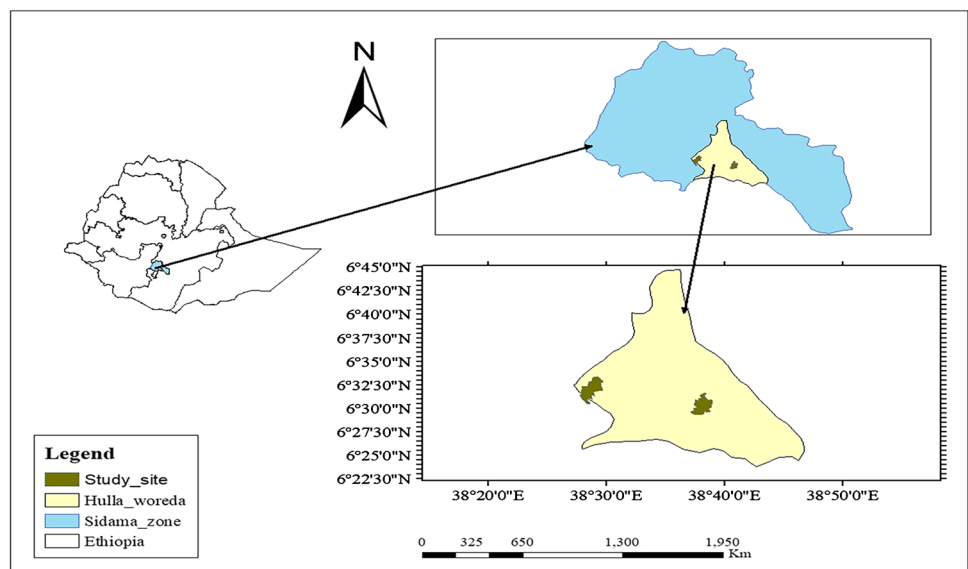
which is mostly rain-fed agriculture. The major crops grown in the study area are cereals (barley/*Hordeum vulgare* and wheat/*Triticum aestivum*); pulses (haricot/*Phaseolus vulgaris*, field pea/*Pisum sativum*, and chickpea/*Cicer arietinum*); oilseed (linseed/*Linum usitatissimum*); vegetables (onion/*Allium cepa* and cabbage/*Brassica oleracea*), tomato/*Solanum lycopersicum*); fruits (apple/*Malus pumila*); and roots and tubers (enset/*Ensete ventricosum*, garlic/*Allium sativum*, sweet pepper/*Capsicum annum*, carrot/*Daucus carota*, and potato/*Solanum tuberosum*).

Sampling techniques and sample size determination

Multistage sampling approaches were used in the investigation. The Hulla district was purposefully chosen in the initial stages. In the second step, communities were stratified into "Dega" (Highland) and "Woyina Dega" (Midland) based on climatic conditions that represent elevation gradients and topographic impacts on temperature, rainfall, and seasonality that govern their capacity to support rain-fed agriculture (Sebastian 2014), and then two villages (Gatama from the highland and Haleka from the midland) were purposively based on their agro-ecological zone.

Finally, sample households (respondents) were selected using systematic random sampling by the probability proportional to size (PPS) approach. The sample size determination method is suggested by the rule of thumb for the sample size determination formula ($N/8m + 50$), where N is the required sample size and m is the number of explanatory factors (Green 2000). Thus, a total of 154 respondents (which is 75 HHs from Hulla Kebele and 79 HHs from Gatama kebele) were selected.

Fig. 1 Map of the study area



The data was collected from both primary and secondary sources. Primary data was gathered through the household (HH) survey, interviews with key informants, and focus group discussions, while secondary data was gathered from a variety of sources, including published and unpublished books, as well as the district’s agriculture office.

Data analysis

The quantitative data was presented using statistical approaches and analyzed using SPSS version 20 (Statistical Package for Social Sciences). The socio-economic characteristics of sampled respondents, farmers’ perceptions of long-term changes in temperature and rainfall, and adaptation strategies were represented using descriptive statistics such as percentages, frequencies, and means, while qualitative data gathered through focus group discussion (FGD), key informant interview (KII), and observational notes were transcribed, arranged, and interpreted. Furthermore, the multinomial logit (MNL) model is used to analyse the determinants of farmers’ choice of adaptation strategies in the study area. MNL is widely employed in climate change adaptation (e.g., Deressa et al. 2009; Sofoluwe et al. 2011) and technology adoption (e.g., Paudel et al. 2011; Jariko et al. 2011) studies. It is employed when the dependent variable has more than two outcomes; in our case, it is used for identify the determinant factors that impact respondents’ adaptation strategies to climate change and variability.

The MNL regression model was used to determine the factors of farmers’ decisions on which adaptation strategies to use in response to climate and variability. This model

allows for the analysis of decisions in more than two categories, as well as the estimation of choice probabilities for different groups. The model, on the other hand, demands that respondents be associated with only their chosen adaptation strategy from a list of options. The possibility of using an adaptation measure for a particular HH is independent of the likelihood of using a possible adaptation strategy.

To describe the MNL model, let y denote a random variable taking on the values $\{1, 2, \dots, J\}$ for J , a positive integer, and let x denote a set of conditioning variables. In this case, y denotes adaptation options or categories and x represents the factors that influence the choice of adaptation strategies, which contain different households, institutional, and environmental attributes (described in Table 1). The question is how *ceteris paribus* changes in the elements of x affect the response probabilities ($P(y = j|x), j = 1, 2, \dots, J$). Since the probabilities must sum to unity, $P(y = j|x)$ is determined once we know the probabilities for $j = 2, \dots, J$.

Let x be a 1_K vector with first element unity. The MNL model has response probabilities given as Eq. (1):

$$p(y = j|x) = \frac{\exp(x' \beta_j)}{1 + \sum_{j=1}^J \exp(x' \beta_j)}, j = 1 \dots \dots \dots j \tag{1}$$

The parameter estimates of the MNL model only show the direction of the relationship between the dependent and independent variables. Therefore, to determine the actual magnitude of change or probabilities, the marginal effect of the explanatory variables, Eq. (1) is differentiated over the explanatory variables to give Eq. (2):

$$\frac{\partial \text{pr}(y=j|x)}{\partial x_k} = p(y = j|x) \left[\beta_{ik} - \frac{\sum_{i \geq 1} \beta_{ik} \exp(x \beta_i P)}{1 + \sum_{i \geq 1} \beta_{ik} \exp(x \beta_i P)} \right] \tag{2}$$

Table 1 Description of independent variables and hypothesis for its effect on dependent variables

Variable	Description	Expected sign
Age	Continuous	±
Gender	Dummy, 1 = male and 0 = female	±
Level of educational	Continuous	+
Family size	Continuous	+
Productive labor force	Continuous	+
Farm size	Continuous	+
Total annual income	continuous	+
Farming experience	Continuous	+
Livestock ownership	Continuous	+
Access to Extension services	Continuous	+
Access to climate information	Dummy (1 = gets information, 0= otherwise)	+
Access to credit	Dummy; 1 = access to credit service, 0 = otherwise	+
Agro-ecology	Categorical, 1 = highlands, 0 = midland	±

The MNL, however, works under the assumption of the independent irrelevant alternatives. Following this assumption, the odds of any two outcomes are independent of the remaining outcomes available. Hence, omitting or adding outcomes should not affect the odds of the remaining outcomes (Long and Freese 2001). The fitted MNL model was first checked to make sure that it does not violate this assumption.

Hypothesized dependent and independent variables

The dependent variables, adaptation measures employed by farmers in the study area included crop diversification with improved varieties, soil and water conservation, Adjusting sowing date, irrigation practice, agroforestry practice, livestock diversification, and off-farm activities. The independent variables and their hypothesized effects are presented in Table 1. In this study, the adaptation theory was based on reviewing previous studies (Deressa et al. 2009; Legesse et al. 2013; Tessema et al. 2013) and to validate the representativeness of these variables, we carried out focus group discussions with key informants.

Result and discussion

Socioeconomic characteristics of household heads

The socioeconomic characteristics of respondents were collected. These included age, gender, educational level, family size, farming experience, and productive labor force and farm size. The study indicated that the mean age of the respondents varied between 26 and 76 (48.43 years on average) which are mostly fallen in the productive age category. The average education level of respondents is around 4 grades. The study also indicated that 91% HHs were male-headed HHs and 9% HHs were female-headed HHs. The family size of respondents ranged from 2 to 18, with mean of almost 7 persons per HH which is little bet greater than reports of CSA (2012) that revealed that on an average, a HH in rural area of the country had about five individuals.

Furthermore, this study indicated that the farm size of respondents varies from 0.2 to 3.5 ha (0.78 ha on average). Respondents had an average of 57.57 years farming experience; the most experienced had 52 years farming experience and the least, 5 years farming experience. Livestock holding is one of the indicators of wealth status and an important component of farming system in the study area. The livestock holding of each HH was calculated in terms of tropical livestock unit (TLU) following Stocker et al. (1991). The HHs' livestock ownership ranged from a minimum of 0 to a

maximum of 15.38 TLU. On an average, the livestock holding of the sampled HH was 3.98 TLU. The annual income distribution of HHs ranged from 3500 to 37,600 Ethiopian Birr (ETB) with an average income of 13,545.52 ETB per year and a s.d. of 3578.75.

The result also revealed that about 91.75% of HHs have access to extension advice with frequency of extension contact ranging from 2 to 15 times per year. This indicated that most of the HHs have better information, appropriate advice, and technical support from experts on agricultural activities which could enhance their ability to adapt to climate-related shocks. This is supported by the reports by Birtukan and Abraham (2016) and Belay et al. (2017) who stated that HHs' access to extension contact is likely to enhance their adoption of climate change adaptation strategies. However, very few (15.3%) had access to funding (microcredit) from regularly registered microfinance institutions. Availability of micro-finance in study area is very low. The result also indicated that most of the farmers (70%) had access to climate information given from the stations (Fig. 2). This suggests that the greater part of the rural farmers in the study area do not utilise the climate information given by the stations, which negatively influences them to do adaptation practices to climate change. Deressa et al. (2008) stated that farmers' access to climate information can enhance and diversify the practices of adaptation strategies to climate change.

Perception of smallholder farmers to climate change

Smallholder farmers who perceive climate change can easily adjust their livelihoods to reduce the adverse effects of climate shocks. Analysis of the data showed that farmers clearly perceive climate change. The result indicated that almost 91% of respondents perceived an increase in temperature within the last three decades. Both the maximum and minimum temperatures from the weather station records show an increase in temperature as shown in Fig. 3.

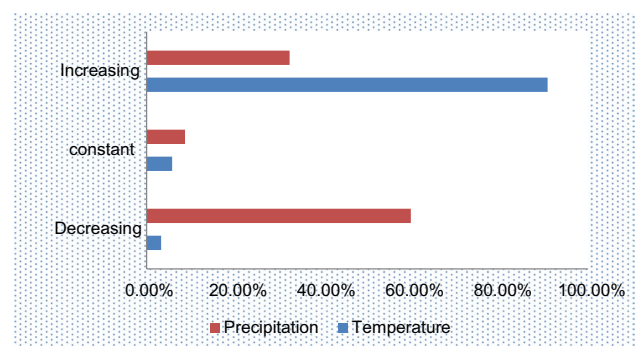


Fig. 2 Farmers' perception of changes in temperature and precipitation

Fig. 3 Trend in average maximum (A) and minimum (B) temperature (°C) 1981–2019

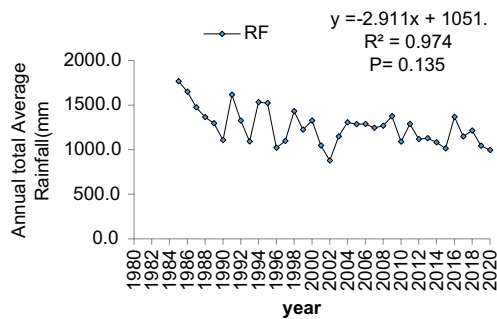
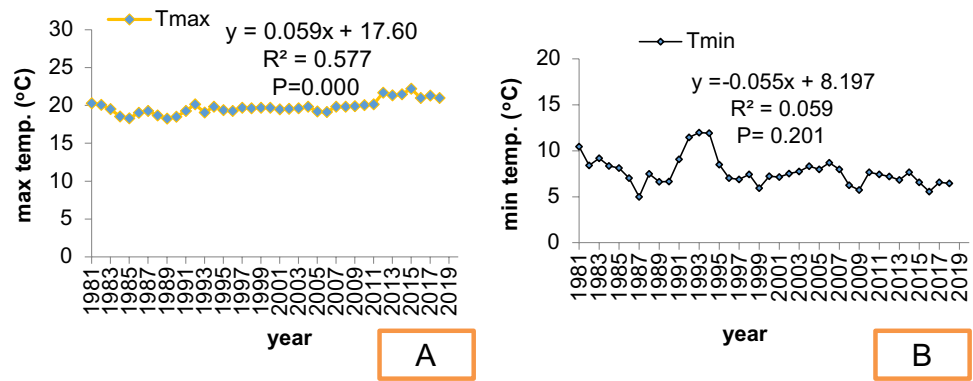


Fig. 4 Trend in average rainfall (mm) 1981–2019

In terms of rainfall, almost 60% of respondents perceived a decrease in rainfall, while about 35% respondents perceived increases of rainfall, within the last 30 years in the study area (Fig. 2). This indicated that the majority of smallholders farmer perceive exist of climate change in their location. FGD and KII also confirmed that decreasing amounts of unseasonal rainfall and increasing drought have occurred in the study area within the last three decades. The general view was that rainfall has being decreasing. This study validates the farmers’ claim with 30 years rainfall data depicted in Fig. 2. There is annual variability shown by the ups and downs in the 40 years rainfall curve. The linear trend line equation shows the decreasing rainfall as follows: $Y = - 2.911 + 1051$ and $R^2 = 0.974$ (Fig. 4).

Smallholder farmers’ adaptation strategies

The present study revealed that about 91% of the respondents have employed different adaptation strategies to adverse effects of climate change (Table 2). The majority of respondents in the study area adopted more than one adaptation strategy against the impact of climate change. Adjusting sowing dates is the most adopted by smallholder farmers (77.9%) as compared to other adaptation strategies. Agroforestry practices (like mango, avocado, coffees, enset, and other trees mixed with crop and livestock rearing) and improved crop varieties under the category of crop-based coping strategies

Table 2 Adaptation practices adopted by households in the study site

Adaptation practices	Percentage of households adopting the practice		
	Highland (n=75)	Mid-land (n=79)	In district (n=154)
No adaptation	12.4	5.2	8.8
Crop-based coping strategy			
Improved crop varieties	68	73.4	70.8
Crop diversification	66.7	60.8	63.6
Livestock-based coping strategy			
Livestock diversification	44.3	41.8	43.05
Planting forage trees	41.3	41.8	41.6
Supplementary feed	36	15.2	25.3
Seasonal migration	6.7	15.2	11
Agroforestry practice	64	81	72.7
Soil and water conservation	59.5	64	61.7
Irrigation practices	30.4	46.7	38.3
Off-farm activities	14.7	31.6	23.4
Adjusting sowing dates	76.7	79.2	77.9

are the second and third most practiced strategies by 72.7% and 70.8% of smallholder farmers, respectively.

Moreover, the present study also revealed that crop diversification (63.6%) and soil and water conservation (61.7%) are well-practiced as adaptation strategies for reducing the impact of climate shocks. Smallholder farmers more commonly practiced livestock-based coping strategy to reduce the adverse effect of climate shock (Table 2). Furthermore, some of the farmers adopted irrigation practices and off-farm activities to reduce the impact of climate shocks.

The present study also revealed that HHs in mid-land agro-ecology were more practices adaptation strategies (that mentioned above) as compared to highland. This indicates that there is more fluctuation of climate conditions in the mid-land of the study area. This is in line with the outcome acquired through focus group discussions and key informant

interviews. The present study also agreed with the reports of Gebrehiwot and van der Veen (2013), Tessema et al. (2013), and Legesse et al. (2013) who reported that the majority of the rural farmers employed different types of adaptation strategies to reduce adverse impacts of climate change in lower and mid-land parts of the country.

Factors affecting households choice of adaptation strategies

Estimated parameter estimates of multinomial logit climate change adaptation model are indicated in Table 3. The explanatory variables under demographic (i.e., gender, age, and family size), human capital (education and farm experience), assets and income (i.e., farm size, TLU, and annual income), access to public services (like extension and information access of credit), and agro-ecological zone (Table 3). The results indicated that all explanatory variables except gender and education level significantly affect the adaptation strategies. In the following section, only the variables that were statistically significant at less than or equal to 10% probability levels are interpreted and discussed.

The results indicated that age of the HH was found to be positively and significantly correlated with crop diversification with improved variety and agroforestry practices at $P \leq 0.1$ and 0.05 , respectively (Table 3). This means that an increase in the age of HH head by 1 year increases the probability of the farmers practicing agroforestry practice by 4% and crop diversification with improved variety by 6.4%. This suggests that older farmers are more likely to have a greater understanding of local climatic conditions and farming experience, as well as the ability to adapt to climate-related shocks. The results are consistent with previous studies of Quayum and Ali (2012) and Birtukan and Abraham (2016), which indicated that older farmers are more likely to use crop diversification as an adaptation strategy than younger farmers. On the other hand, age of the HH head showed a unit increase in the age of the HH decreases the probability of farmers using irrigation practices by 1% at $P \leq 0.05$ as an adaptation strategy (Table 3).

Moreover, the result revealed that family size is positively and significantly correlated with farmers' adoption of soil and water conservation practices and agroforestry practices. Farmers are more likely to use soil and water conservation as adaptation strategies by 6.5% at $P \leq 0.05$ and agroforestry practices as adaptation strategies by 1.1% at $P \leq 0.1$ as the family size increases by one unit. This indicates that larger family sizes are more likely to use soil and water conservation and agroforestry as adaptation strategies to reduce the negative consequences of climate change.

The study also revealed that the productive labor force is positively and significantly correlated with soil and water conservation practices and irrigation practices (Table 3). One unit increases the productive labor force (the number

of family members aged 16 to 64), which increases the probability of farmers adopting soil and water conservation by 3.1% ($P \leq 0.05$) and irrigation practices by 3.2% ($P \leq 0.05$). This indicates that respondents with more active labor have a better chance of exploring alternative adaptation strategies in the face of climate change's negative impacts. This result lines with Nhemachena and Hassan (2007) who reported that the larger active labor force is positively related to soil and water conservation practice.

Furthermore, the current data shows that farm size has a positive and significant relationship with crop diversification as a strategy for adaptation. When farm size is increased by 1 ha, the probability of using crop diversification with improved varieties as an adaptation strategy increased by 93.8% ($P \leq 0.01$) (Table 3). This indicates that farmers with larger farmland can more easily adopt crop diversification adaptation strategies than farmers with smaller farmland. This finding is consistent with Gbetibouo (2009) and Tessema et al. (2013), who found that farmers with larger landholdings are more likely to make investments in crop diversification and crop varieties as adaptation strategies to reduce the effect of climate shocks.

This study also revealed that adjusting sowing dates, agroforestry practices, and livestock diversification have a positive and significant impact on agricultural experience. Farmers with more than one year of agricultural experience are 33.3% more likely to adjust sowing dates, 14.4% more likely to adopt agroforestry, and 11.4% more likely to diversify livestock (Table 3). This implies that experienced farmers are more likely to have greater information and knowledge about changes in climatic conditions, enabling them to more easily respond to climate change shocks. This finding is supported by the findings of Maddison (2007), Gbetibouo (2009), and Deressa et al. (2014).

Additionally, the findings showed that the number of livestock held has a positive and significant association with the use of irrigation and livestock diversification as adaptation strategies. At $P \leq 0.1$, an increase in livestock by one unit increased the probability of adopting an irrigation strategy by 41.9% and livestock diversification by 74.8% (Table 3). This implies that farmers with larger herds have a better chance to earn adequate money to invest in the resources and technology for irrigation and livestock diversification. Similarly, Deressa et al. (2011), Haftu et al. (2016), Ali and Erenstein (2017), and Belay et al. (2017) found a statistically significant association between livestock ownership and crop diversification with improved varieties.

Farmers who have easy access to extension services in their area may participate in activities which can be used as adaptation strategies. The results of this study indicated that access to extension services has a positive and significant effect on soil and water conservation. Increased access to extension services increases the chance of farmers adopting soil and water conservation as a climate change and variability adaptation strategy by 32.6% ($P \leq 0.01$) (Table 3). The study revealed that easily

Table 3 Marginal effects from the multinomial logit climate change adaptation model

Explanatory variables	Crop diversification with improved varieties		Soil and water conservation		Adjusting sowing date		Irrigation practices		Agroforestry practices		Livestock diversification		Off-farm activity	
	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value
Age	-0.063	0.001***	-0.02	0.829	0.342	0.342	-0.01	0.022**	0.04	0.059*	0.015	0.649	-0.16	0.206
Gender	0.357	0.682	0.566	0.648	0.638	0.424	0.531	0.693	0.886	0.465	2.252	0.899	0.686	0.619
Education	0.148	0.443	0.037	0.846	0.221	0.267	0.005	0.651	0.052	0.792	0.06	0.825	-0.09	0.719
Family size	0.035	0.902	0.648	0.031**	0.041	0.868	0.013	0.972	0.011	0.073*	0.331	0.264	0.242	0.522
Productive labor	0.005	0.991	0.314	0.043**	0.049	0.89	0.319	0.047**	0.141	0.381	0.06	0.354	0.251	0.136
Farm size	0.938	0.001***	0.311	0.794	0.555	0.338	0.978	0.426	0.119	0.927	0.245	0.886	-0.32	0.818
Annual income	0.878	0.003***	0.547	0.0002***	0.872	0.338	0.927	0.056*	0.245	0.025**	0.245	0.886	-0.25	0.571
Farm experience	0.062	0.721	0.045	0.648	0.333	0.040**	0.012	0.898	0.14	0.011**	0.114	0.020**	-0.04	0.679
TLU	2.072	0.168	1.527	0.34	0.133	0.933	0.419	0.083*	0.011	0.994	0.748	0.073*	-0.67	0.715
Extension	0.012	0.904	0.326	0.005***	0.122	0.432	0.077	0.495	0.075	0.506	0.075	0.631	-0.14	0.285
Information	0.855	0.308	0.378	0.661	0.765	0.025**	0.85	0.056*	0.918	0.049**	0.847	0.286	-0.15	0.88
Credit	-0.085	0.925	-0.46	0.699	-0.153	0.884	0.071	0.053*	-0.09	0.933	-0.431	0.506	-0.77	0.003***
Agro-ecology	0.185	0.819	-0.04	0.962	0	1	-0.19	0.821	0.671	0.495	-0.154	0.858	0.515	0.095*
constant	1.131	0.018**	-0.75	0.197	0.208	0.669	5.969	0.000***	0.617	0.574	-0.154	0.785	1.458	0.087*

Coef.: coefficient

Base category = no adaptation; number of observations = 154; LR χ^2 (78) = 218.323; Log likelihood = -97.2101; Prob > χ^2 = 0.0000; pseudo R^2 = 0.6165

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

accessible experts greatly assisted farmers in adopting soil and water conservation activities as an adaptation strategy to minimize the impact of climate shocks. This finding is consistent with the findings of Fentie et al. (2013) and Belay (2015), where a positive relationship between extension services and climate change adaptation measures was observed.

Furthermore, access to climate information has a substantial impact on farmers' climate change adaptation strategies. When climate information is increased by one unit, farmers' adoption of adjusting sowing dates with climate conditions increased by 76.5% ($P \leq 0.05$), irrigation techniques increased by 85% ($P \leq 0.1$), and agroforestry practices increased by 91.8% ($P \leq 0.05$) (Table 3). This shows that climate information has the potential to improve farmers' understanding of changing climate conditions and possibly practices of irrigation and agroforestry activities as an adaptation strategy, but weather prediction information is not adequately shared by concerned bodies. Similarly Deressa et al. (2009) and Debalke (2013) noted that providing farmers with adequate information on climate conditions allows them to adopt improved crop varieties as climate change adaptation options.

Moreover, the results indicated that the access to finance had significant positive and negative effects on the choices of adaptation strategies. Specifically, the results show that access to credit was found to be positively and significantly correlated with irrigation practices but negatively correlated with off-farm activities as a climate change adaptation strategy. A one-unit increase in credit access improved the likelihood of farmers adopting irrigation by 7% ($P \leq 0.1$). This suggests that one of the most important factors influencing farmers' decisions to engage in irrigation activities is the availability of financial resources such as credit facilities in rural areas.

Finally, the current study shows that the agro-ecological zone is positively and significantly associated with off-farm activities. The MNL model found that smallholder farmers in the midland are more likely to use off-farm activities as adaptation methods than farmers in the highland. This disparity may be attributed to farmers in the midland experiencing a scarcity of rainfall and significant variability resulting in a loss in agricultural output compared to those in the highland. This finding is in line with the findings of Tesso et al. (2012) and Legesse et al. (2013) that farmers living in different agro-ecological areas have distinct options for adapting to the effects of climate change.

Conclusions

The majority of smallholder farmers in the study area have perceived long-term changes in temperature and rainfall and their impact on their livelihoods. As a result, they have implemented various adaptation strategies to mitigate the negative effects of climate change. Crop diversification with

improved varieties, soil and water conservation, adjusting sowing dates, irrigation practice, agroforestry, livestock diversification, and off-farm activities have been identified as the main adaptation strategies of farmers. The findings also revealed that, while respondents used various strategies to combat the effects of climate change, some factors limited respondents' ability to practice adaptation strategies. The main factors influencing farmers' decisions to implement adaptation strategies are the drawbacks of extension services, a lack of financial resources, a lack of climate change information, a lack of farm experience, and the limits of farmers' annual income. The findings also revealed that farmers' adaptation tactics were influenced by their age, family size, farm size, number of livestock, and agro-ecological zones. As a result, raising climate change awareness and distributing information about agricultural practices among farmers is a critical step in promoting adaptation measures to mitigate the effects of climate change. Farmers should have access to reliable and accurate weather forecasts through the establishment of a local agro-meteorological station. To address the financial shortfalls in the study area, local decision-makers and microfinance organizations should provide loan access. In addition, an adequate adaptation measure for a specific agro-ecological zone is essential.

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Declarations

Competing interests The authors declare that they have no competing interests.

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