Determinants of Climate Change Adaptation Strategies among Smallholder Farmers in Haramaya District, Ethiopia: A Cross-sectional Study

Habtamu Abaynew[1,*], Nasir Ahmed[2], Nuredin Hassen[3], and Birhanu Argaw[4]

[1] Department of Agricultural Economics, Dilla University, P.O. Box –419, Dilla, Ethiopia
[2] Department of Climate Change and Disaster Risk Management, Haramaya University, P.O. Box –138, Haramaya, Ethiopia
[3] Department of Horticulture, Dilla University, P.O. Box –419, Dilla, Ethiopia
[4] Department of Agricultural Economics, Bonga University, P.O. Box –334, Bonga, Ethiopia

* Email of the corresponding author: habtamuabaynew23@gmail.com

Abstract

In Ethiopia, particularly in the Haramaya District, livelihoods are heavily dependent on subsistence rain-fed farming, making communities highly vulnerable to climate change. Enhancing the resilience of smallholder farmers, therefore, depends on successful adaptation to changing climatic conditions. This study examines the adaptation strategies of smallholder farmers in Haramaya District, Oromia National Regional State, Ethiopia, which is severely affected by climate change, using both primary and secondary data. Primary data were collected through household surveys of 189 randomly selected smallholder farmers, Focus Group Discussions (FGDs), and Key Informant Interviews (KIIs), while secondary data were obtained from previous studies and official reports. The data were analyzed using descriptive statistics and a multinomial probit model. The findings of the study revealed that smallholder farmers in the study area adopted various climate change adaptation strategies, with changing livestock type being the most common (22.75%) and altering the planting period being the least common (16.40%). Other strategies included soil and water conservation (22.22%), income source diversification (20.63%), and cultivating drought-tolerant crops (17.99%). Furthermore, the multinomial probit model results showed that age, access to climate information, livestock holdings, irrigation access, education level, extension visits, active labor size, and access to credit significantly influenced farmers' adaptation choices in response to climate change. The findings underscore the importance of strengthening institutional and policy support for smallholder farmers. Additionally, concerned government bodies and development partners should prioritize improving access to credit, enhancing climate change awareness, expanding extension services, promoting education, and investing in long-term climate mitigation and adaptation initiatives to build farmers' adaptive capacities and ensure sustainable livelihoods.

Keywords: Adaptation strategies, Climate change, Haramaya district, Multinomial probit model, Smallholder farmers

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1. INTRODUCTION

Climate change is placing increasing pressure on global agriculture, and its impacts are projected to intensify in the future (Apata et al., 2009; Lobell et al., 2011; Rosenzweig et al., 2014). The 21st century poses a critical challenge for agriculture: how to feed a growing global population while confronting issues such as soil erosion, water scarcity, and limited resources, all compounded by shifting dietary patterns (Tubiello, 2012). Despite significant technological advancements, many regions still heavily rely on the environment to sustain agricultural productivity (Müller et al., 2011). In fact, Parry (2007) warned that climate change could reduce agricultural production by up to 50% in rain-fed farming regions by 2020.

While developed nations are expected to face the most severe impacts of climate change (Ericksen et al., 2011; Skoufias et al., 2011), Africa - a continent responsible for only 3.6% of global emissions - is among the hardest hit (Parry, 2007; Alemneh, 2011). Sub-Saharan Africa (SSA), with its reliance on rain-fed agriculture, is particularly vulnerable to climate-related disruptions (Cooper et al., 2008). Consequently, poorer nations and households will bear the heaviest burden. Ethiopia, with its agriculture-dependent economy, is one of the most vulnerable countries in SSA (Conway and Schipper, 2011).

Agriculture plays a central role in Ethiopia's economy, yet the country struggles to meet growing food demands due to climate-induced challenges (World Bank, 2007). As Deressa (2007) notes, climate-related disasters—especially droughts and floods—have had devastating effects on the agricultural sector. In particular, the rural areas of Haramaya Woreda are highly vulnerable to climate change and variability, facing degraded natural resources and exacerbated risks due to global warming. Reports highlight recurring droughts in the district, which, alongside temperature and rainfall fluctuations, contribute to both droughts and floods, intensifying the region's challenges (Haramaya woredas Administration Environmental Protection Authority (HWEPA), 2011).

To mitigate these impacts, adaptation strategies are essential. These strategies aim to reduce the severity of climate-induced damage and are vital for safeguarding agricultural productivity. Understanding how farmers perceive climate change and adapt to it is crucial in developing effective adaptation measures.

Numerous studies have examined climate-related issues in Ethiopia, particularly focusing on farmers in the Nile Basin (Deressa et al., 2010; Rengler et al., 2009; Hassan et al., 2008; Yesuf et al., 2008). While these studies provide valuable insights for policy interventions at the micro level, especially for farmers in similar socio-economic and climatic conditions, a one-size-fits-all approach is not ideal. The variation in agro-ecological zones means that adaptation strategies must be tailored to local contexts. As adaptation is inherently localized, methods vary not only between communities but also within them. Customizing these strategies is essential to effectively mitigate the adverse impacts of climate change on smallholder farmers.

2. RESEARCH METHODOLOGY

2.1. Description of the Study Area

The study was conducted in the rural kebeles of Haramaya District, located in the eastern part of Ethiopia, approximately 505 km from Addis Ababa, the capital city. Haramaya is bordered by Kurfa Chele to the south, Kersa to the west, Dire Dawa to the north, Kombolcha to the east, and the Harari Region to the southeast. Geographically, the district lies at coordinates 41°59'58" N latitude and 09°24'10" E longitude. Haramaya Woreda is subdivided into 34 rural kebeles and 2 urban kebeles. The district's altitude ranges from 1,900 to 2,450 meters above sea level, encompassing three agro-ecological zones: *Dega* (highland), *Woinadega* (midland), and *Kola* (lowland). The mean annual rainfall is 74.1 mm, with a mean annual temperature of 16.9°C. The dry season, characterized by less than 30 mm of rainfall per month, extends from October to February, while the main autumn rains occur between September and November, and the smaller spring rains take place from March to May (Haramaya Woreda Administration Disaster Preparedness and Food Security Office (HWADPFSO), 2015).

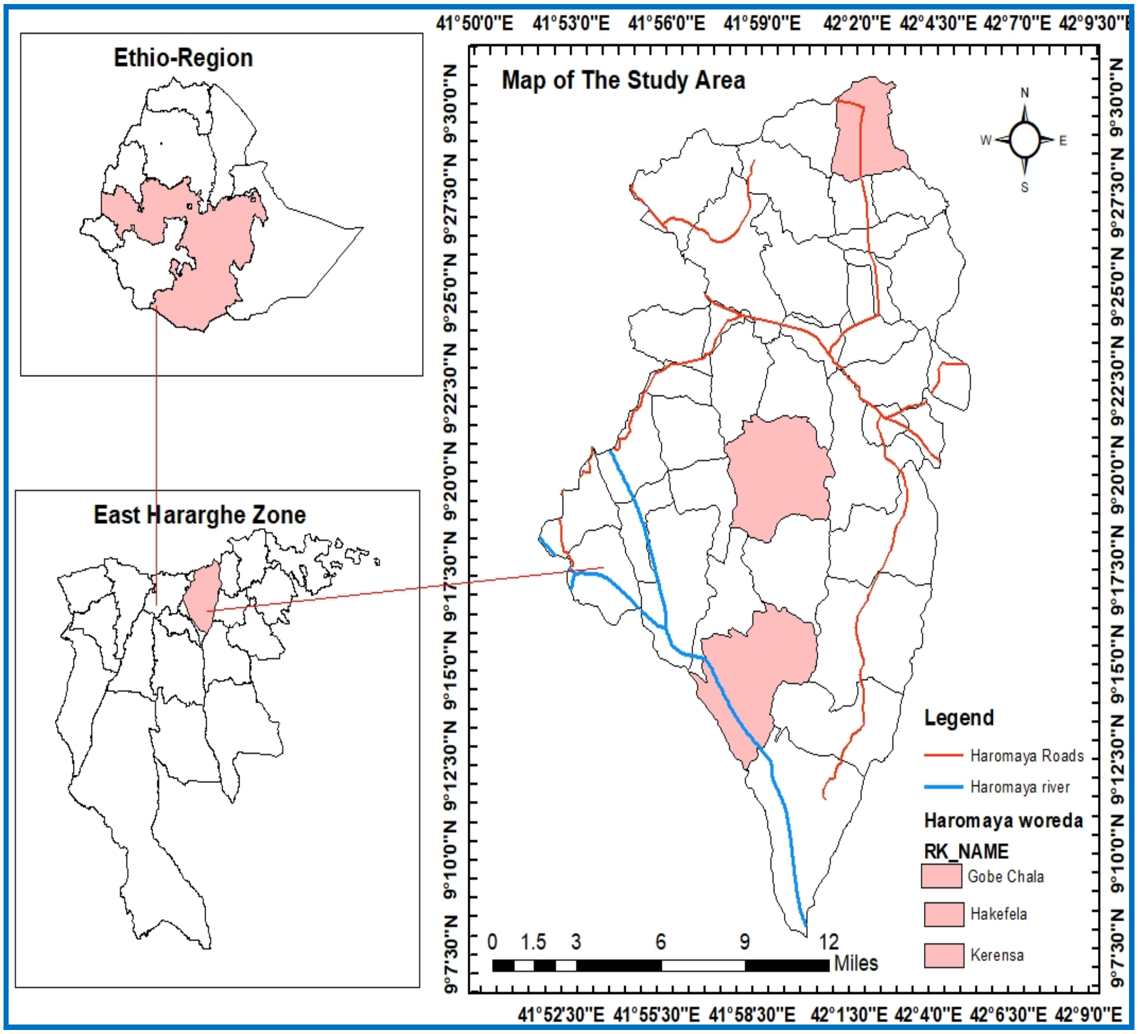

Figure 1: Location Map of Haramaya District

2.2. Sampling Technique and Sample Size

Haramaya District, comprising 34 kebeles and two towns, served as the study area for this research. To ensure a representative sample, the researchers employed a stratified random sampling technique, dividing the 34 kebeles into three distinct agro-climatic zones: highland (*Dega*), midland (*Woinadega*), and lowland (*Kola*). One kebele was selected from each zone: *Haqa Fila* from the lowland, *Gobe Chala* from the highland, and *Kerensa Sharif Kalid* from the midland. From these selected kebeles, 7% of households were randomly chosen from the household lists, with the sample size allocated proportionally based on the number of households in each kebele. Specifically, *Gobe Chala* had 800 households, *Haqa Fila* had 978, and *Kerensa Sharif Kalid* had 673. To determine the required sample size, the study utilized Yamane's (1967) simplified formula, applying a precision level of 7%. This calculation yielded a final sample size of 189 households, ensuring a robust and statistically reliable representation of the district's diverse agricultural contexts.

$$n = \frac{N}{1 + N\,(e)^2}$$

$$\text{n} = \frac{2451}{1 + 2451(0.07)^2}$$

$$\text{n} = 189$$

Where n is the sample size, N is the population size (total household) and e is the level of precision. The above formula requires a minimum of 189 sampled households as the total number of households which is 2451.

Table 1: Distribution of Sampled households by sample kebeles

Kebeles	Sample households	Sample size	Percentage
Gobe Chala	800	62	32.5%
Haqa fila	978	75	40%
Kerensa sherif kelid	673	52	27.5%
Total	**2451**	**189**	**100%**

2.3. Data Type and Methods of Data Collection

Both qualitative and quantitative data were collected from primary and secondary sources to explore smallholder farmers' adaptation strategies to climate change in Haramaya District. Primary data were gathered using four main methods: household surveys, focus group discussions, and key informant interviews. The household survey, conducted with 189 randomly selected respondents, was translated into Afan Oromo to ensure effective communication with participants. Focus group discussions were held in the selected kebeles, with eight participants in each group representing different age groups, genders, and socio-economic statuses. These discussions focused on farmers' perceptions of climate change, particularly changes in rainfall patterns, temperature, and extreme weather events, as well as coping mechanisms and adaptation strategies.

Key informant interviews involved sixteen individuals, including ten community key informants (five male and five female farmers) and three development agents at the kebele level, as well as three experts from the Woreda level, specializing in agriculture, natural resource conservation, and disaster risk management. Secondary data were obtained from various sources, including previous research, official websites, unpublished documents, and publications from government offices, such as regional, zonal, and district agricultural offices. This multi-method approach enabled a comprehensive understanding of both the context and the factors influencing adaptation strategies.

2.4. Analytical Methods

The data collected from both primary and secondary sources were analyzed using a combination of qualitative and quantitative methods, including descriptive analysis and the econometric multinomial probit model. Qualitative data gathered through focus group discussions (FGDs) and key informant interviews (KIIs) were analyzed using a critical review technique to extract in-depth insights. For the quantitative analysis, descriptive statistics—such as means, percentages, and frequencies—were employed to assess farmers' adaptation strategies and to examine the socio-economic characteristics of the sample households. This comprehensive approach allowed for a thorough understanding of both the numerical patterns and the underlying qualitative factors influencing adaptation strategies.

2.4.1. Multinomial probit model

Farmers are more likely to adopt a combination of adaptation strategies to cope with the diverse risks and challenges induced by climate change, rather than relying on a single approach. Analytical methods commonly used to study adaptation decisions with multiple choices include the multinomial logit (MNL) and multinomial probit (MNP) models. However, many existing studies on climate change adaptation strategies fail to account for the potential interrelationships between different strategies (Yu et al., 2008). For example, Nhemachena and Hassan (2007) used the multinomial probit model to analyze factors influencing adaptation choices in Southern Africa.

In response to adverse climatic changes, farmers tend to adopt a mix of strategies to maximize mitigation efforts, leveraging the complementary benefits of various options. Adaptation is also path-dependent, with earlier strategies influencing future decisions. To accurately estimate the impact of external factors on the adoption of adaptation strategies, it is crucial to use a model that accounts for the simultaneous influence of these factors while allowing for the correlation of error terms across strategies. Failure to do so can lead to biased estimates (Kassie et al., 2013). Therefore, this study employs a multinomial probit model to identify the factors influencing smallholder farmers' choice of adaptation strategies in response to climate change.

The researchers follow Lin *et al.,* (2005) in formulating the multinomial probit model which has one dependent variables (adaptation strategy) but five outcomes, y1 (changing planting period), y2 (soil and water conservation practice), y3 (change livestock type), y4 (income source diversification) and y5 (Growing drought tolerant crops) such that;

yi=1 $if \beta ix'$+εi>0, and

$yi=0\ if\ \beta ix'+\varepsilon i\leq 0$

Where i=1, 2,3,4…,189; x is a vector of the explanatory variables; $\beta 1$, $\beta 2$, $\beta 3$, $\beta 4$, and $\beta 5$ are conformable parameter vectors and $\varepsilon 1$, $\varepsilon 2$, $\varepsilon 3$, $\varepsilon 4$ and $\varepsilon 5$ are random errors distributed as a multivariate normal distribution with zero mean, unitary variance and correlation matrix. Thus, the dependent variable in the empirical estimation for this study is the choice of an adaptation decision(s) from the set of adaptation measures such as soil and water conservation practices, income source diversification, changing livestock type, growing drought tolerant crops as major climate change adaptation strategies and changing planting period. But, choice of an adaptation decision(s) was determined by a number of factors. This model was also used to examine the trade-offs and complementarities that existed between the strategies that adapted by farmers. This technique simultaneously models the influence of the set of explanatory variables on each of the different strategies while allowing for the potential correlation between unobserved disturbances, as well as the relationship between the strategies of different practices (Kassie et al., 2009).

2.5. Definition of Variables and Working Hypothesis

Dependent variable

For this study, the dependent variable is the choice of adaptation mechanisms most pursued by smallholder farmers in the study district. The choice of adaptation options is assumed to be done among completely mutually exclusive alternatives based on the assumption of multinomial probit model. It is categorical variable and includes the following adaptation strategies: Changing planting period, Soil and water conservation practice, Change livestock type, Income source diversification, and Growing drought tolerant crops.

Explanatory variables

Based on the findings of past studies on climate change adaptation strategies, the following variables were hypothesized to affect climate change adaptation strategies of smallholder farmers in the study area.

Table 2: Summary of Variables, Definition, and Measurement

Variables	Type	Definition	Measurement
Dependent variable			
Adaptation strategies to climate change	Categorical		
Explanatory variables			
Age	Continuous	Age of household head	Year
Education level	Continuous	Education level of household head	Class completed
Access to credit	Dummy	Access to credit	1 if access 0 other wise
Sex	Dummy	Sex of household head	1 if access 0 other wise
Distance to market	Continuous	Distance from home to the nearest market	kilometer
Climate information	Dummy	Access to climate information	1 if access 0 other wise
Cultivated land size	Continuous	Cultivated land size	Hectare
Household farm income	Continuous	Annual on-farm income	Birr
Active labor size	Continuous	Household member whose age is between 15 and 65	Number
Livestock holding	Continuous	Total livestock holding	Tropical Livestock Unit (TLU)
Irrigation access	Dummy	Access to irrigation water	1 if access 0 otherwise
Extension visit	Continuous	Extension visit	Number

3. RESULTS AND DISCUSSION

This chapter presents the results of the study on climate change adaptation strategies and attitudes of farmers using data obtained from 189 sample households, focus group discussions and interviews with key informants. It has two parts. The first segment describes the adaptation strategies adopted by smallholder farmers in the study area. The second section presents econometric outcomes of the determinants of the climate change adaptation strategies of smallholder farmers in the study area.

3.1. Households adaptation strategies to climate change

In the study area of the research, farmers have adopted various strategies to mitigate the impact of climate change and large proportions of farmers have experienced climate change in recent years. The sampled farm households were subsequently asked whether they had responded to the effects of climate change by adaptation. They announced that in order to reduce the negative effects of climate change, they are using various adaptation strategies. Changing the planting cycle, soil and water management practices, changing the form of livestock, diversification of revenue sources and increasing drought resistant crops were the most commonly followed strategies used by households. The findings of the survey indicate that about 60.85 percent or 115 sampled households practiced more than one climate change adaptation technique.

Changing the planting cycle is one of the most adaptive choices used to cope with the adverse effects of climate change in the study areas. In the study district, as an adaptation technique, 16 percent of sampled households used shifting planting times to reduce the adverse impact of climate change on their farms.

Environmental degradation, manifested in the degradation of land resources, is one of the major challenges facing farmers in the study area in striving for growth. Soil and water conservation strategies are commonly adapted by farmers, given the magnitude of the moisture stress in the study field. Out of the total sampled households, about 22 percent of households used soil and water conservation as an adaptation strategy to reduce the adverse impact on farm production of climate change. Among the soil and water conservation techniques commonly used by farmers in the study field, soil/stone bunds, tie ridge and manure application are among soil and water conservation techniques, while changing their form of livestock is the least practiced among the major adaptation techniques of the study *kebeles*.

The descriptive statistics result also showed that out of the total sample households, 23 percent of the sampled households are also using change livestock type as an adaptation mechanism. Moreover, around 21 percent of the sampled households used diversification of income sources, and 18 percent of the households used growing drought-tolerant crops as methods of adaptation to crops.

Table 3: The widely used adaptation strategies to climate change by smallholder farmers

Strategies	Frequency	Percentage
Changing planting period	31	16.40
Soil and water conservation	42	22.22
Change livestock type	43	22.75
Income source diversification	39	20.63
Growing drought tolerant crops	34	17.99

3.2. Econometric Model Results

3.2.1. Regression Diagnostics

Before estimating the multinomial probit model, it was necessary to check for outliers and if multicollinearity exists among the explanatory variables considered for analysis. The reason for this is that the existence of multicollinearity will affect seriously the parameter estimates. If multicollinearity turns out to be significant, the simultaneous presence of the two variables will attenuate or reinforce the individual effects of these variables. In short, the coefficients of the interaction of the variables indicate whether or not one of the two associated variables should be eliminated from model analysis (Kotari, 1990).

Thus, prior to estimating the parameters of the model, the regression diagnostics was done to check whether it follows the assumption of regression or not. Variance Inflation Factor (VIF) was checked for the existence of multicollinearity between all the explanatory variables included in the model using SPSS - version 20. The variance inflation factor for all explanatory variables was less than 10 which indicate that multicollinearity is not a serious problem in the model (Table 4).

Table 4: Variance Inflation Factor (VIF) for continuous variable

Variable	VIF	TOL
Education level	1.80	0.554831
Extension visit	1.51	0.664000
Household farm income	1.33	0.753762
Active labor size	1.31	0.765100
Cultivated land size	1.19	0.843022
Age	1.18	0.843921
Livestock holding	1.10	0.910464
Distance to market	1.09	0.917724
Mean VIF	1.31	

In addition, there may be interaction between dummy variables, which can lead to the problem of multicollinearity. To detect this problem, coefficients of contingency was computed from the survey data. The contingency coefficients (CC) was done on SPSS version 20 and the result showed absence of strong association between the different discrete explanatory variables, since the respective coefficients were very low (less than 0.75) (Table 5).

Table 5: Contingency Coefficients (CC) for Dummy Variables

Variable	Contingency Coefficient (CC)
Irrigation access	0.196
Access to credit	0.107
Climate information	0.180
Sex	0.043

3.3.2. Determinants of Farmers Choice of Adaptation Strategies to Climate change

Multinomial probit model was employed to estimate the parameters of the explanatory variables expected to determine farmer's choice of adaptation strategies to climate change presented in Table 6. The goodness-of-fit was tested by the Log likelihood ratio (LR) test. The result showed that Wald chi2 is 423.21 and prob > chi2 = 0.00. This means that χ^2 is statistically significant and the model displays a good fit. The Pseudo R^2 of the model is 0.73, implying that 73% of the variation in the choice of adaptation strategies to climate change was explained by the 12 explanatory variables included in the model. This verifies that the model has a good fit to the data and explained significant non-zero variations in factors influencing households' adaptation strategies to climate change.

Multinomial probit model employed to identify the determinants of farmer's choice of adaptation strategies to climate change in the study area using the cross-sectional data from 189 sample households. Accordingly, variables hypothesized to have influence on the farmer's choice of adaptation strategies to climate change were fitted in the model. To act in response to climate change and decrease its negative effects, changing planting period, soil and water conservation practice, changing livestock type, income source diversification and growing drought tolerant crops adaptation strategies are used by farmers in the study area as a major climate change adaptation strategy. However, there are a number of factors which influence households' choice to prefer a particular adaptation option.

The results of the multinomial probit model showed that the decision to choose a certain adaption strategy to climate change and variability depends on a number of factors. Out of 12 variables included in the model, eight variables were statistically significant. Namely, access to climate information and formal extension services, household education level, the age of the household head, household farm size and household income the study areas were reported as some of the factors that affect adaptation strategies to climate change in the study area. We reported here only those factors that significantly affected the choice of adaptation options to be implemented (Table 6).

Age of the household head: The survey result indicated that the age of the household head had positively impacted the decision to practice change in crop type, change livestock type, and income source diversification as an adaptation strategy to climate change in the study area and significant at 5%, 5% and 1%

probability level, respectively (Table 6). The positive sign showed that age of household head increases the probability to take up adaptation measures. This is because older farmers have long years of experience to notice changes in their environment and take up adaptation measures. This means as the age of household head increases by a year, the probability to change the planting period, change livestock type, and income source diversification as climate change adaptation option will increase by probability of 0.2%, 0.15% and 0.12%. The result of the study is in line with Nhemachena and Hassen (2007). Thus, it can be inferred from the result that age of the farm households was one of the factors in the choice of adaptation strategies to climate change.

Educational level: It was a significant determinant to choose change livestock type as an adaptation strategy to climate change at 5% probability level. Household education level and changing livestock type as an adaptation strategy to climate change were positive correlated, implying that educated farmers are expected to adopt new livestock breeds based on their awareness of the potential benefits of the proposed climate change adaptation measures (Table 6). A year increase in school level of education of the farm household leads to an increase in the probability of changing livestock type as an adaptation option by 1.5%. The survey result is in line with the finding of Hassan and Nhemachena (2008).

Active labor size: As expected, active labor size had positive and significant relationship with changing the planting period and income source diversification as an adaptation strategy to climate change in the study area at 5% probability level. The positive sign showed that the probability of changing planting period and income source diversification were high for households where active (productive) members are greater than inactive (unproductive) members (Table 6). Other variables remaining constant, as the active labor size (15-65 years) increase by a unit, the probability that the household use changing planting period and income source diversification as an adaptation strategy to climate change increase by 3.2% and 4.6%, respectively.

Access to formal extension services: It had positive and significant influence on the probability of growing drought tolerant crops as climate change adaptation measures at 5% significance level (Table 6). The post estimation result of marginal effect implied that an increase in extension visit by one lead to an increase in the probability of smallholder farmers to adopt growing of drought tolerant crops as an adaptive strategy in response to climate change by 3.4%. This result agrees with Nhemachena and Hassen (2007), and Alemayehu and Bewket (2017).

The finding of the study suggests that extension service is an important source of information on climate change impacts and adaptation strategies and improved provision of extension services for modern farming practices should be encouraged. Ifeanyi-obi *et al.* (2012) suggested that extension agents need to be well groomed in climate change adaptation strategies that are relevant to the farmers' particular environment.

Access to climate information: is one of the most important variables that affect the decision of smallholder farmers to choose certain adaptation options to climate change in the study district. Smallholder farmers, who have access to climate information, get a higher probability of implementing climate change adaptation options. Access to climate information had a positive effect on farmer's decision to use changing of livestock type and income source diversification as an adaption strategy to climate change and significant at 5% probability level (Table 6). The marginal effect result indicated that the probability of farm households who had access to climate information to practice changing of livestock type and income source diversification was higher than their counterparts by 0.08% and 0.2%, respectively, considering other factors remaining constant. The finding of the study is in line with Alemayehu and Bewket (2017).

Access to climate information, provided by the national meteorological agency, significantly increased farmers' choice of adaptation options. This indicates that a household that had better access to weather information made better informed about adaptation decision. Household with regular access to official weather information is more likely to change the crop selection for the upcoming growing season as an adaptation option. This implies that the provision of weather information and services at the local level will increase the adaptive capacity of the agricultural communities. Hence, the information on agricultural practices needs to be complemented with seasonal weather forecasts and should be supported by extension agents' advice. This can help farmers adjust to the seasonal variation in the onset and cessation of rainfall by changing their planting dates, crop choices and timely agricultural planning. Apart from the national meteorological services, it is also important to develop and increase the availability of localized forecasts to improve reliability and spatial-temporal resolution of the services to smallholder farmers.

Access to irrigation: It had negative relationship with soil and water conservation adaptation strategy to climate change and significant at 10% probability level. This implies that the probability to use soil and water conservation adaptation strategy to climate change decreased with access to irrigation. However, access to irrigation had positive impact on smallholder farmer's decision to grow drought tolerant crops in response to climate change, implying that the probability to grow drought tolerant crops adaptation strategy to climate change increased with access to irrigation (Table 6). The marginal effect result show that, as compared to household who did not have access to irrigation, the probability of the access to irrigation households to use soil and water conservation and growing drought tolerant crops as an adaptation strategy was lower by 3.2 % and higher by 12.7%.

Irrigation, as one of the technology options available, enables smallholder farmers to directly produce consumable food grains and/or diversify their cropping and supplement moisture deficiency in agriculture and helps to increase production and food consumption without affected by climate change.

Table 6: Determinants of adaptation choice to climate change: Multinomial probit model

Explanatory Variables	Changing planting period		Soil and water conservation		Change livestock type		Income source diversification		Growing drought tolerant crops	
	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value
Sex of the household head	-0.136	0.841	-0.201	0.526	0.210	0.528	-0.003	0.999	0.041	0.904
Age of the household head	0.054	0.014**	0.0188	0.366	0.041	0.036**	0.059	0.005*	-0.030	0.183
Educational Level Household head	-0.048	0.407	-0.096	0.103	0.118	0.042**	-0.022	0.695	0.090	0.131
Active labor size	0.337	0.019**	-0.069	0.610	-0.219	0.107	0.288	0.042**	0.209	0.121
Frequency of extension visit	0.012	0.949	0.175	0.343	-0.202	0.084	0.027	0.884	0.372	0.048**
Access to credit	0.629	0.308	0.887	0.112	-1.00	0.084*	0.114	0.839	-0.436	0.424
Distance from market	-0.005	0.841	0.014	0.540	0.011	0.603	-0.026	0.262	-0.001	0.956
Cultivated land size	-0.341	0.534	-0.229	0.644	-0.375	0.444	0.605	0.233	-0.477	0.361
Household farm income	0.02	0.225	-0.001	0.354	0.000	0.715	0.002	0.196	0.000	0.567
Livestock holding in TLU	-0.323	0.627	0.039	0.542	0.068	0.275	-0.107	0.091*	0.0137	0.833
Access to climate info	-0.136	0.373	0.124	0.710	0.682	0.047**	-0.806	0.021**	0.235	0.490
Access to irrigation	-0.529	0.337	-0.917	0.072*	0.386	0.460	0.531	0.292	0.919	0.083*
Constant	0.721	0.45	0.069	0.941	-1.29	0.157	1.23	0.191	-0.102	0.917
Number of observations	189									
Log likelihood	-32.33									
LR chi2 (19)	423.21									
Prob > chi2	0.00									
Pseudo R^2	0.73									

Note: ***, ** and* significant at 1%, 5%, and 10% probability level of significance

The result of the post estimation (marginal effect and the likelihood probability) showed that the likelihood of households to use changing planting period, soil and water conservation practices, diversification of their income sources, change livestock type, and growing drought tolerant crops were 16.69%, 22.32%, 15.25%, 28.92% and 16.82%, respectively.

Table 7: The probability of using different adaptation strategies to climate change

Adaptation strategies	Likelihood
Changing planting period	16.69%
Soil and water conservation practices	22.32%
Diversification of their income sources	15.25%
Change livestock type	28.92%
Growing drought tolerant crops	16.82%

4. SUMMARY, CONCLUSION AND RECOMMENDATION

4.1. Summary and Conclusion

Ethiopia is highly vulnerable to the impacts of climate change due to its dependence on rain-fed agriculture, recurring droughts, and limited adaptive capacity. These climate impacts disrupt planting and harvesting cycles, reduce crop yields, and increase the risk of crop failure, directly threatening household’s livelihood. In response, this study aims to investigate the factors influencing farmers' adaptation strategies to climate change in the study area. Cross-sectional data were gathered from three rural kebeles in Haramaya

District, involving 189 randomly selected households surveyed using a semi-structured questionnaire, focus group discussion, and key informant interviews. The data were analyzed through descriptive statistics and a multinomial probit econometric model. Specifically, descriptive statistics were used to provide insights into farmer's perception of climate change, type of adaptation strategies to climate change and multinomial probit model was employed to identify determinants factors affecting farmer's decision to use climate change adaptation strategies.

The descriptive statistics result showed that changing livestock type is the most common adaptation method, reported by 43 households (22.75%). This is followed by soil and water conservation practices, adopted by 42 households (22.22%). Income source diversification ranks third with 39 households (20.63%) utilizing this approach. Growing drought-tolerant crops accounts for 17.99%, reported by 34 households. Lastly, changing the planting period is the least common strategy, adopted by 31 households (16.40%). These findings highlight that farmers are implementing diverse strategies to cope with climate change, with a focus on livestock and resource management.

The results of the multinomial probit model revealed that access to climate information and formal extension services, household education level, the age of the household head, household farm size and household income were the major factors that affect adaptation strategies to climate change in the study area.

The result of the study indicated that the likelihood of households to use changing planting period, soil and water conservation practices, diversification of their income sources, change livestock type, and growing drought tolerant crops were 16.69%, 22.32%, 15.25%, 28.92% and 16.82%, respectively.

4.2. Recommendations

Based on the findings of this study, the following recommendations have been made for local policy makers and stakeholders in the district.

The level of perception of farmers to climate change has a significant effect on the level of using adaptation strategies to lessen the effect of climate change. But there are still a considerable number of farmers who did not perceive the changing climate. Therefore, emphasizing on awareness creation about the changing climate is crucial.

Policy interventions aimed at mitigating the adverse effect of climate change need to focus on supporting farmers to intensively use and capitalize the existing adaptation strategies are growing drought tolerant crops, changing planting period, soil and water conservation, Income source diversification and change livestock type.

Intensifying efforts to improve awareness and adaptive capacity of farmers through improving provision of extension service, encouraging farmer-to-farmer extension services and motivating using of media is very critical. It is necessary to encourage informal social networks and discussions at farmer's level so that enable them to share information and experiences which are important for choice of appropriate adaptation strategies. Farmers also need to be encouraged to use different media like radio, extension agents, neighbors/ village, and traditional leaders/elders to get access to climate information so that they will be able respond to climate change.

Policies aimed at awareness creation about climate change and adaptation strategies need to be framed considering agro-ecological setting and gender for effectiveness of interventions. Promotion of a given adaptation strategies should consider the agro-ecological setting of the area and gender difference needs special consideration for successful use of adaptation measures by smallholder farmers.

It is necessary to design and implement policies that aim to expand adult education so that improve education level of farmers. Literate farmers could be able to easily collect, analyze and interpret relevant information about climate change and adaptation strategies. It will enable them to select appropriate adaptation strategies and farming practices to manage climate change impacts. Hence, it is essential to improve education level of farmers through expansion of adult schools and crafting systems that allow farmers to get education.

Creating opportunities for a diversified farm and off/non-farm income sources for the farmers is important. Higher income increases the purchasing power of farmers and enables them to easily meet the cost of farm inputs like drought tolerant variety, inputs for irrigation use like water pump, seeds, seedlings and fertilizer. Hence, adequate farm inputs need to be available to improve farm income and creation of alternative off-farm income source is very imperative.

The government and other stakeholders also need to inspire farmers who have large landholding size for effective adaptation to climate change. They should suggest appropriate adaptation strategies to practice through extension. On the other side, farmers with small landholding should be encouraged for efficient use of successful adaptation to climate change. Policy interventions should also focus on transforming the livestock husbandry system from traditional way to modern. It helps to mitigate the land, time and labor requirement.

Promoting farmer's access to credit is vital to secure immediate need of money for the very purpose of purchasing farm inputs and meet the costs associated with using various adaptation strategies: growing drought tolerant crops, changing planting period, soil and water conservation, Income source diversification and change livestock type. Therefore, the outreach and availability of formal credit providers that can be accessed with affordable interest rate need to be increased to improve farmer's financial capacity.

Finally, the researchers recommend that further study need to be done on the impact of each adaptation strategies in improving the livelihood of farmers and alleviate the problem of climate change impacts in the district.

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