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Factors Affecting Adaptation Strategies of Smallholder Farmer's to Climate Changes: Evidence from Dale Woreda in Sidama Regional State: Ethiopia

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Abstract: The objective of this study was to analyzing factors that affect smallholder farmers' choice of adaptation strategy and identifies adaptation measures to climate change in Ethiopia using Dale Woreda as a case study. The data was collected from 359 sample households using a survey questionnaire and was analyzed using both descriptive statistics and econometric methods. Multinomial logit model (MNL) was used to identify factors influencing smallholder farmers' choice of adaptation strategies to climate change and variability. The adaptation strategies considered in the MNL model were crop diversification, growing drought tolerant crop, soil and water management, early and late planting and small scale irrigation practice. The result from the multinomial logit analysis showed that sex, education, farm experience, family size, farm income, farm size, distance to the market, soil fertility, access to credit, access to climate information, and extension access were significant factors influencing smallholder farmers' adaptation strategies. a unit increases in number of years of education could increase 8.1% of the likelihood of adopting crop diversification, 1.8% of the likelihood of adopting growing drought tolerant crop and 1.2% of the likelihood of early and late planting as adaptation measures. The basic barriers to climate change adaptation on the farmers' side are lack of credit access, lack of knowledge, lack of support from government, shortage of farm land, lack of climate information and lack of climate related problem. Therefore, expanding extension service, improving the availability of credit and enhancing research on use of new crop diversification and distributing drought tolerant crop varieties and encouraging continuous climate training center, disseminating climate information by local language through social media and providing modern tool for soil and water management and small scale irrigation by government are more suited in three agro-ecological zones.

Keywords: Climate Change, Adaptation, Adaptation Strategy, Multinomial Logit Model, Dale Woreda

1. Introduction

The impacts of climate change are experienced to changing degrees across and within countries due to contrast in exposure, susceptibility and coping capacities. Small holder farmers in sub -Sahara region in general and eastern Africa countries in particular are facing considerable multifaceted challenges developing States, face disproportionate risks from an altered climate, while high-income countries are generally less vulnerable and more resilient. Within countries, people living in poverty and other vulnerable groups including smallholder farmers, indigenous peoples and rural coastal populations are more vulnerable to climate alter and incur greater looseness from it, while having fewer resources with which to cope and recover. Climate change can generate a vicious cycle of increasing poverty and vulnerability, worsening inequality and the already precarious condition of many disadvantaged groups [16, 10]. Moreover, adaptation is critical and necessary in developing countries, especially in Ethiopia where the fact that vulnerability is high. Most people of livelihoods and living standard are affected by the impact of climate change. Farmers with better knowledge and information on climate change and agronomic practices enable to use adaptation methods to cope up with change in climate and other socioeconomic conditions. A better understanding of the local dimensions of climatic change is also essential to develop appropriate adaptation measures that can mitigate the adverse impact of climate change. Therefore, awareness of the potential benefits from any adaptation is very important issue [1].

This prediction and expectation coupled with the current situation worries all citizens especially in developing countries. For example, if we take Ethiopia, the agricultural sector which is the backbone of the country's economy is entirely dominated by smallholder farmers who are very vulnerable and sensitive to climate change related problems. Thus, owing to this fact, the effort should focus on finding mechanisms in which smallholder farmers can reduce these problems and save their lives.

1.1. Literature Review

Climate change is caused by the emission of greenhouse gases into the earth's atmosphere through both natural processes and human activities; though growing evidence demonstrates the largest contribution is from the latter. The burning of fossil fuels, largely as a result of transportation, is the primary contributor to the emission of carbon dioxide while processes such as deforestation and industrial agriculture are the main contributors to the emission of methane and nitrous oxide compounds into the atmosphere. Despite constituting less than 15% to total GHG emissions, methane is a very strong greenhouse gas which is 23 times stronger than CO_2 [7, 9].

Agriculture is ranked as the most susceptible sector to climate change impacts and so do the livelihoods of subsistence farmers and pastoralists. Climate change exerts multiple stresses on the biological, physical, social and institutional environments that affect agricultural production. Its impacts disproportionately affected Sub-Saharan African countries including Ethiopia because of the higher dependency of their economies on climate-sensitive activities such as rain-fed agriculture. Some of the induced changes are expected to be immediate, while others involve gradual shifts in temperature, vegetation cover and species distributions. Climate change is expected to and in parts of Africa has already begun to alter the dynamics of drought, rainfall and heat waves, and trigger secondary stresses such as the spread of pests, increased competition for resources, and biodiversity losses [7, 15].

To decrease vulnerability and build the resilience of ecological and social systems and economic sectors to react current and future adverse effects of climate change in order to minimize the problem agricultural production, human health, livelihoods, food security, assets, amenities, ecosystems and sustainable development. There are many different strategies that farmers can implement to reduce the risk of climate change impacts. Farmers use different adaptation strategies that match with the types of the climate related problems they faced [2].

This is due to the fact that impact of the climate change is not evenly distributed over different geographic areas and hence the adaptation mechanisms also vary with types and amount of the impact of climate change. Therefore, we can find a number of adaptation strategies that the farmers used to reduce the impact of climate change in different literature. This includes: crop diversification, small scale irrigation, changing crop variety, changing planting dates, mix crop and livestock production, decrease livestock, moving animals/temporary migration, change livestock feeds, soil and water management, planting trees, planting drought tolerant crop, change from livestock to crop production, change animal breeds, seek off-farm employment, planting short season crop, and irrigation/water harvesting are among some of the several strategies available to enhance social resilience in the face of climate change [4, 5].

1.2. Problem of the Statement

Agriculture is the most important sector in sub-Saharan Africa, including Ethiopia, but it is predicted to be negatively impacted by climate change. It is clear that climate change was brought about substantial welfare losses especially for smallholders whose main source of livelihood derives from agriculture. As site specific issues require site specific knowledge, it is very important, therefore, to clearly understand what is happening at community level, because farmers are the most climate vulnerable group. In the absence of such location specific studies, it is difficult to fine tune interventions geared towards achieving effective and efficient adaptation options to cope with the adverse impact of climate change at the local [12, 13].

Farmers of dale woreda are, like farmers in any other part of Ethiopia, is suffering from Climate upheavals which have become common natural disasters in the country. First, there has been more erratic and unreliable rainfall in the rainy seasons, bringing drought and reduction in crop yields and plant varieties; the rainfall especially in the later rains towards the end of the year has been reported as coming in more intense and destructive downpours, bringing floods, landslides and soil erosion. Second, there has been a fluctuation in temperature which disturbs the physiology of crops, the micro-climate, and the soil system on which they grow. Third, the crop production has been recurrently hit by erosion, and floods. Fourth, annual river runoff and water availability has been reported to decrease dramatically. Food insecurity in the area is a major challenge and all these climate shocks have exacerbated the negative impacts on the livelihood of poorer farm households as they have the lowest capacity to adapt to changes in climatic conditions [13].

However, farmers in the study area were responded to climate change through various adaptation strategies. But, there was no empirical data that substantiates or supports the existing adaptation strategies practiced by the farmers in the area. The information obtained in various literatures was insufficient and general, but adaptation strategies vary contextually and spatially (within communities and even within individuals). In this regard, no empirical study has been conducted to identify adaptation choices, examine the perception of farmers to climate change and their determinants in the study area to date to the best of the researchers' knowledge. Consequently, the primary motive to embark on this research was to investigate and fill the existing gap of knowledge on farmers' perception and adaptation strategies to changing climate and their determinants in the study area.

1.3. Research Gap

The determination and understanding of cumulative and combined impacts of factors affecting smallholder farmer's adaptation strategies to climate change. The most of empirical literature carried out on demographic, socio-economic and institutional factors affecting adaptation strategies to climate change is debatable because they come up with different conclusion on the same independent variable about climate adaption strategies to climate alter. For example, regarding to age of household according to [6] and [9], elderly farmers were more active and experienced in farming activities than youths. On the contrarily way, the investigation conducted by [6] shows that even though there is high variability in the ages of the sampled households, generally the household within the productive age that can fully and efficiently engaged in agricultural activities than elderly people.

1.3.1. Research Question

This study was attempted to answer the following questions:

1) What are the determinant components that influence farmers' choice of adaptation strategies to the climate change in dale woreda?
2) What are the adaptation measures that were employed by farmers in study site?
3) Did farmers perceive the existing climate change?

Specific objective of the study:

1) To analyze the factors that impact farmers' choice of adaptation strategies to climate change in Dale woreda.
2) To identify adaptation strategies used by farmers in response to adverse effects of climate change in the study area.
3) To analyze farmers' perception to climate change.

1.3.2. Research Methodology

Determining sample is very important issue because samples that are too large may waste time, resources and money while samples too small may lead inaccurate results.

As discussed in the above section, kebeles being differ in both in terms of size and variability of agro-ecological zone; they was different level of adaptation strategies to climate change. Using data on climate change and small holder farmers' characteristics the number of survey producers per division was computed according to the formula developed by Yamane (1967) because it is simplest formula to calculate sample sizes and its importance in small sample size to solve resource and time constraint. $n=\frac{N}{1+N(e)^2}$

Where n is the sample size, N is the population size (total number of household heads in selected kebeles), and e is the level of precision. n =367 is the total sample size planned to be covered.

The Sample Size (n) for Precision (e) of 5% where confidence level is 95% will be $n=\frac{N}{1+N(e)^2}=\frac{4518}{1+4518(0.05)^2}=367$.

It is assumed that the sample will have 95% reliability about population and sampling error will be 5%. The selected sample size will be identified from six kebeles by proportionate random sampling.

At this stage, to give equal chance and free from selection bias, a total of 367 households of respondents was selected from the respective list of farmers which is complete list of households in each kebele obtained from the woreda administration and kebele offices in 6 kebeles by using systematic sampling technique. The list kebeles covered by size of ultimate sampling unit was determined by using proportionate sampling technique giving a size of 640, 762, 852, 806, 788 and 670 from wenenata, hidaqalite, soyama, kalitesimita, shiifa and Beera respectively.

Table 1. *Sample kebeles and sample size determination.*

Kebeles	No of hh	Proportion of each kebele	Sampling for each kebele	Sample size
Wenenata	640	0.14	367*0.14	51
Hidaqalite	762	0. 17	367*0.17	62
Soyama	852	0.19	367*0.19	70
Kalitesimita	806	0.18	367*0.18	66
Shiifa	788	0.17	367*0.17	63
Beera	670	0.15	367*0.15	55
Total	4518	1		367

Source: Dale woreda rural development and agricultural office

2. Theoretical Model

In this study it is interesting and necessary to develop theoretical framework on farm household. This theoretical framework draws on adopting a version of model based on the random utility model as specified by [11]. This random utility model is commonly used as a framework in determining of farmers' choice for different adaptation options. We can specify a common formulation of linear random utility model as;

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

Following Greene (2003), we can modify it to adapt the objective of the study. Where, i = 1,…., N are the individual farmer and j = 1,….. J are the alternative adaptation methods, Xij vector are the factors that influence farmers' choice an adaptation method to climate change and εij is the random error term /disturbance term. To elaborate the model, we assume that farmers' are rational decision makers who maximize the utility from adaptation strategies in their farming activities. And also assuming that farmers face climatic change in their farming activities was looked for adaptation strategies.

If farmer i make choice j adaptation in particular, then we assume that Uij is the maximum utility among the J adaptation methods.

$$\text{Prob (Uij > Uik) for all other } k \neq j.$$

The probability of that a particular farmer will choose a particular alternative j is given by the probability that the utility of that alternative to the farmer is greater than the utility to that farmer of all other alternative J.

2.1. Multinomial Logit Model

Multinomial logistic regression is a simple extension of binary logistic regression (takes only two categories of the dependent) that allows for more than two categories or levels of the dependent or outcome variable and is easy, simple in calculating the choice probability and expressible in analytical form [15] and [17]. MNL model is appropriate for this study because MNL model is the simplest and often preferable compared to more complex multinomial probit to identify factors affecting adaptation strategy of smallholder farmers to climate change. MNP is susceptible to a number of estimation problems, the most serious of which is that the MNP is often weakly identified in application to analyze factors affecting the choice of adaptation strategy of smallholder farmer to climate change. Weak identification is difficult to diagnose and may lead to plausible, yet arbitrary or misleading inferences. The main limitation of the model is the independent of irrelevant alternative (IIA) property, which states that the ratio of the probability of choosing any two alternatives is independence of the attributes of any other alternative in the choice set [8] and [17] The multinomial probit (MNP) model specification for discrete choice model does not require the assumption of the IIA [8] and [17]. The MNL model was used by many researchers to the model climate change adaptation practices of smallholder farmers [3] and [4]. Therefore, the multinomial logit model is appropriate to the model of climate change adaptation practice of smallholder farmers in this study area.

The Multinomial logit model for the adaptation choice can be specified as in the following relationship between the probability of choosing option and a set of explanatory variables X [11].

$$\text{Prob(Yi = j)} = \frac{e^{\beta' j\, Xi}}{\sum_{k=0}^{5} e^{\beta' kxi}}, \; j = 0, 1, 2, 3, 4, 5 \qquad (1)$$

Equation (1) is normalized to remove indeterminacy in the model by assuming $\beta_{0=0}$ and the probabilities can be estimated as:-

$$\text{Prob(Yi = j/xi)} = \frac{e^{\beta' j\, Xi}}{1+\sum_{k=0}^{j} e^{\beta' kxi}}, \; j = 0,1,2, J, \beta_{0=0} \qquad (2)$$

Maximum likelihood estimation of equation (2) yields the log-odds ratio

$$\ln\left(\frac{Pij}{Pik}\right) = X'(\beta_j - \beta_k) = X_i'\beta_j, \text{ if } k=0 \qquad (3)$$

The dependent variable of any adaptation option is therefore the log of odd in relation to the basealternative. According to Greene (2003), the MNL coefficients are difficult to interpret and associating the β_j with the jth outcome is tempting and misleading. Marginal effect is useful to interpret the effect of independent variable on the dependent variable in terms of probabilities.

$$\frac{\partial Pj}{\partial Xi} = P_j\left(\beta_j - \sum_{k=0}^{j} P_k\beta_j\right) = P_j(\beta_j - \beta) \qquad (4)$$

The marginal effects, measure the expected change in probability of a particular choice being made with respect to a unite change in explanatory variable [11].

2.2. Independence of Irrelevant Alternative (IIA) Test for MNL Model

As it is discussed earlier, the multinomial logit model requires the fulfillment of the assumption of the Independence of Irrelevant Alternatives (IIA), otherwise the model is not appropriate. Different literatures suggest different ways to handling the problem of IIA and to test the fulfillment of the assumption. For instance, McFadden (1973) forwarded that models with independence of irrelevant alternative assumption should be used in cases where the alternatives can plausibly be assumed to be distinct and weighted independently in the eyes of each decision option. Moreover, Multinomial logit models are work well when the alternative is dissimilar. Beside, two most commonways that are used to test Independence of irrelevant alternative (IIA) are [8] and [14].

In this model six categorical outcome tests of IIA are reported here. Then the study computed the model using no adaptation strategy as a base category. The study was used [8] and [17] test of independence of irrelevant alternatives.

Statistical and Specification Tests

Before carry out the final model regressions, all the hypothesized explanatory variables were checked for some statistical problems such as the issue of multicollinearity. Basically, multicollinearity problem may arise due to a linear relationship among explanatory variables and the problem is that, it might cause the estimated regression coefficients to have wrong signs of coefficients, smaller t-ratios for many of the variables in the regression and high R-square value. Besides, it causes large variance and standard errors with a wide confidence interval. Hence, it is quite difficult to estimate accurately the effect of each variable on the dependent [8]. There are different methods suggested to detect the existence of multicollinearity problem between the model explanatory variables.

Correlation Matrix method will be used to detect the degree of association explanatory variables. These variables are said to be collinear if the value of the coefficient correlation Matrix is greater than 0.75.

2.3. Definitions Research Variables Used in the Model

Independent variable is climate change adaptation strategies.

3. Dependent Variables

The dependent variable for multinomial logit model of this study was adaptation strategies that the sample households employed in response to climate change. The choice of adaptation strategies was based on the actions the sample households take to counteract the negative impact of climate change/variability. From previous researches, different climate change adaptation methods have been identified. The researcher was asked numerous alternative adaptation strategies to the sample respondents and finally identified five major adaptation methods most commonly used in the area as dependent variable for the multinomial logit model. These included crop diversification, changing planting dates, use of water and soil management practices, use of drought tolerant varieties and use of irrigation.

Table 2. *Summary of definition, measurement and hypothesis of explanatory variables.*

Independent Variable	Crop Diversification Expected sign	Growing drought tolerant crop Expected sign	Soil and water management Expected sign	Changing planting date Expected sign	Small scale Irrigation Expected sign
Age	+	+	+	+	+
Sex	+	+	+	+	+
Education	+	+	+	+	+
Farm experience	+	+	+	+	+
Off-farm income	+	+	+	+	+
Farm income	+	+	+	+	+
Credit access	+	+	+	+	+
Market distance	-	-	-	-	-
Farm size	+	+	+	+	+
Family size	+	+	+	+	+
Soil fertility	+	+	+	+	+
Extension access	+	+	+	+	+
Access to climate information	+	+	+	+	+

$$Yi = \beta_0 + \beta 1age + \beta 2sex + \beta 3edu + \beta 4fex + \beta 5ofi + \beta 6cra + \beta 7c + \beta 8mkd + \beta 9fas + \beta 10fms + \beta 11sof + \beta 12aci + \beta 13exa + ei \quad (5)$$

Where: Yi are the climate change adaptation strategies that are currently being used to deal with climate change and others are demographic, institutional and socio economics factors.

Where β_0 is constant, β_k are regression and coefficients ei error term.

4. Data Analysis

4.1. Descriptive Analysis Method

Under this section the responses of the farm households of Dale Woreda was analyzed by using descriptive statistical method. The results found in this part could help for the later econometric methods in section 4.3. Additionally, it is also important for analyzing some of the necessary information which is not easily captured by the econometrics methods.

4.2. Background Characteristics of Respondents

This section summarizes the demographic characteristics of respondents, which includes gender, and age. The purpose of the demographic analysis in this research is to describe the characteristics of the sample respondents accordingly, and the following tables provide the demographic profile of the respondents.

Table 3. *Demographic Characteristics of Respondents.*

Variables	Categories	Frequency	Percentage
	Male house hold head	195	54.3
Sex	Female	164	45.7
	Total	359	100
	15-30	47	13.2
	31-40	134	37.3
Age	41-50	125	34.8
	51-64	53	14.7
	Total	359	100

Source:- own survey data, 2022

From the data presented in the above table 3, the majority (54.3%) of the respondents were male and the remaining (45.7%) of the respondents were female. This indicates that out of 359 household respondent, around 195 household head were male and the remaining 164 were female. This shows that most of the household head of the farmers are male.

As indicated in table 3 among the total gathered questionnaire, 13.2% of the respondents were found to be in the age category of 15-30 years. The respondents who compose of 37.3% are in the age category of 31-40 years, 34.8% in the age categories of 41-50, and 51-64 are 14.7 This data indicated that most of the respondents categorized between age group of 31-40.

Table 4. *Social Characteristics of Respondents.*

Variables	Categories	Frequency	Percentage
Education status	Illiterate	178	49.5%
	1-6	87	24%
	7-12	64	17.8%
	Certificate/Diplom	22	6.2%
	Degree	8	2.5%
	Total	359	100
Respondent farm experience	1-10	97	27%
	11-20	111	30.9%
	21-30	110	30.6%
	>30	41	11.5%

Source: Own survey data, 2022

4.3. Educational Status

As shown in the above table 4, the majority of the respondents were grouped under the educational level of respondent are illiterate covering 49.5% of the total respondents, followed by 1-6 composes 24%. The respondents were categorized under the educational level of 7-12 who covers 17.8%, and 6.2% and 2.5% are certificate/diploma and degree holder respectively. This shows that most of the smallholder farmers are illiterate.

From the above table 4, indicated that 30.9% smallholder farmer have experience of between 11-20 years; 30.6% had an experience of 21-30 years; 27% had between 1-10 years and the remaining 11.5% of the respondents had experience of greater than 30 years with in farm. This indicated that majority of respondents had found under 11-20 years' of farm experience.

Table 5. *Economic Characteristics of Respondents.*

Variables	Categories	Frequency	Percentage
Off farm income	No off farm income	218	60.7
	500-1000	63	17.5
	1001-1500	32	8.9
	1501-2000	20	5.6
	>2000	26	7.3
	Total	359	100
Farm income	No income	44	12.3
	500-1000 Birr	186	51.8
	1001-1500 Birr	96	26.7
	1501-2000 Birr	17	4.7
	>2000	16	4.5
	Total	359	100

Source: Own survey data, 2022

Considering the off farm income characteristics of the respondents, majority of the smallholder farmer have no off farm income; who fall to 60.7%, followed by respondents 17.5%, 8.9%, 5.6% and 7.3% who off farm income 500-100, 1001-1500, 1501-200 and greater than 2000 respectively. The income category clearly shows the majority (51.8%) of the smallholder farmer have farm income between 500-1000and 12.3% of the respondent have no farm income and the remaining 26.7%, 4.7% and 4.5% have income between 1001-1500, 1501-2001 and greater than 2000 respectively.

Table 6. *Cross tabulation of agro-ecological zone and adaptation decision.*

Agro-ecological zone	Types of adaptation strategy practiced	Number of respondent who took strategy	Type of adaptation practice in percent (%)
Woyna-Dega	Crop diversification	64	39.3%
	Growing drought tolerant crop	8	4.9%
	Soil and water management	25	15.3%
	Changing planting date	12	7.4%
	Small scale irrigation	7	4.3%
Dega	Crop diversification	11	17.2%
	Growing drought tolerant crop	2	1.2%
	Soil and water management	21	33.3%
	Changing planting date	4	6.9%
	Small scale irrigation	3	4.8%
Kola	Crop diversification	4	3%
	Growing drought tolerant crop	56	42%
	Soil and water management	18	13.1%
	Changing planting date	7	5.3%
	Small scale irrigation	16	12%

Source: Own survey results, 2022

The above table shows that, about 39.3% of the respondents from Weyna-dega agro ecological zone had used crop diversification as primary choice of adaptation strategy to climate change followed by soil and water management (15.3%), 15.3%, 7.4% and 4.9% had practiced soil and water management, changing planting date and growing drought tolerant crop respectively and on other side; only 4.3% had used small scale irrigation as least used adaptation strategy. The result indicated that most of smallholder farmers used crop to reduce consequences of climate change in the Weyna-dega agro-ecological zone of study site. The above table shows that about 33.3% of the respondents from dega agro-ecological zone had used soil and water management as their major choice of adaptation strategy to cope with the impact of climate change followed by crop diversification (17.2%) and Growing drought tolerant crop is least choice of adaptation strategy to moderate climate change in dega agro-ecology of the Woreda.

4.4. Summary Statistics for Explanatory Variables

Table 7. *Sum agehh sex fex edu ofi fai cra mkd fms fas sof aci exa.*

Independent variables	Description	Summary statistics			
		mean	**Std. Dev.**	**Min**	**Max**
Age of household	continuous variable	2.5125	.8995554	1	4
Sex	Dummy 1 if male, otherwise	.84958220	.357979	0	1
Farm experience	Continuous in year	2.264624	.9828995	1	4
Education	Continuous	.8718663	1.051875	0	4
Off farm income	In ETB (continuous variable)	1.785515	1.26677	0	5
Farm income		2.37325	.9184382	1	5
Credit access	Dummy 1 if yes, 0 otherwise	.6991643	.4592615	0	1
Distance from farm to market farm	Continuous in km	2.509749	.9271146	1	5
Farm size	Continuous in hectare	2.34818	.9680314	1	4
Family size	continuous	2.07799	.942207	1	4
Soil fertility	Categorical 1 very fertile, 2 for moderate fertile and 3 infertile	1.793872	1.793872	1	3
Access to climate information	Dummy 1 if yes, 0 otherwise	.5933148	.4919008	0	1
Extension access	Dummy 1 if yes, 0 otherwise	.6406685	.4804742	0	

Source: Own survey data, 2022

4.5. Factors that Affecting Smallholder Farmers' Choice of Adaptation Strategies in the Study Area

Estimated results of the multinomial logit regression model showed how factors that affecting farmers' choice of adaptation strategies in the study area. The MNL adaptation model was run and showed that significant levels of the parameters estimates. Table 8 represents that the results of MNL regression model. The likelihood ratio statistics as indicated by ch2 statistics (LR chi-square (65) = 649.46 and Pseudo R2 = 0.5421 are highly significant P < 0.0000), explaining the model has a strong explanatory power. In all cases, the estimated coefficients should be compared with the base category of no adaptation. Therefore, Table 8 presents the MNL results along with the levels of statistical significance.

Table 8. *Parameter estimates of the multinomial logit climate change adaptation model mlogit adastrategy agehh sex fex edu ofi fai cra mkd fms fas sof aci exa.*

Explanatory variable	Crop Diversification	Growing Drought tolerant crop	Soil and water Management	Changing Planting date	Small scale irrigation
	Coef p-value	**Coef p-value**	**Coef p-value**	**Coef p-value**	**Coef p- value**
Age	.154 (0.639)	.063 (0.867)	.358 (0.33)	.275 (0.715)	.032 (0.931)
Sex	-1.371 (0.434)	6.030 (0.001**)	6.836 (0.00**)	12.163 (0.000**)	-14.983 (0.990)
Education	1.285 (0.000**)	2.067 (0.000**)	1.149 (0.003 **)	1.34 (0.037**)	.879 (.0.029**)
Farm experience	2.314 (0.000**)	1.316 (0.001 **)	2.162 (0.000**)	2.296 (0.009**)	1.852 (0.001**)
Off farm income	.876 (0.017**)	.039 (0.924)	1.149 (0.003**)	.637 (0.227)	.185 (0.682)
Farm income	3.222 (0.000 **)	3.245 (0.007**)	2.505 (0.018**)	1.216 (0.575)	5.533 (0.000**)
Credit access	2.558 (0.005**)	3.407 (0.001**)	4.125 (0.000**)	-.444 (0.811)	2.379 (0.032 **)
Market distance	-2.804 (0.000**)	-2.965 (0.008**)	-3.166 (0.001**)	-3.120 (0.139***	-3.987 (0.000**)
Farm size	4.016 (0.000**)	4.276 (0.000 **)	4.786 (0.000**)	6.447 (0.000 **)	4.076 (0.000**)
Family size	.701 (0.072***)	.985 (0.030**)	1.250 (0.004**)	1.519 (0.207***)	1.419 (0.002**)
Soil fertility	1.530 (0.020**)	4.101 (0.000l**)	3.773 (0.000 **)	1.734 (0.173***)	1.589 (0.032**)
Access to climate information	1.381 (0.063***)	1.791 (0.027**)	2.349 (0.004 **)	-1.683 (0.316)	.960 (0.240)
Extension access	3.222 (0.000**)	2.393 (0.008**)	3.328 (0.000 **)	2.903 (0.085***)	18.686 (0.979)
Base category				No adaptation	
Number of observation				359	
LRchi2 (65)				649.46	
Prob > chi2				0.0000	
Loglikelihood				-274.30607	
Pseudo R2				0.5421	

NB *, **, *** = significant at 1%, 5%, and 10% probability level, respectively
Source; own survey data 2022

Coefficient from the multinomial logit model can tell about the direction effect not the magnitude effect. How to compute the magnitude of effect by using stata-15 command mfx after multinomial logit regression and it results marginal effect. Marginal effect of marginal probabilities is the function of probabilities and measures the expected change in probabilities where particular adaptation choice is being made by a unit change of the independent variable from the mean.

Table 9. *Marginal effects of explanatory variables from multinomial logit model.*

Independent variable	Crop diversification	Growing drought tolerant crop	Soil and water management	Changing planting date	Small scale irrigation
	Marginal effect	**Marginal effect**	**Marginal effect**	**Marginal effect**	**Marginal effect**
Age	-.0143	-.022	.041	.000	-.000
Sex	.688	-.070	-.334	-.330	.001
Education	.081	.018	-.000	.012	-.000
Farm experience	.034	.017	.016	.011	-.000
Off farm income	.193	.091	-.087	.000	-.000
Farm income	.141	.053	-.107	-.003	.000
Credit access	.133	.093	.232	-.015	-.000
Market distance	.018	-.023	-.076	-.005	-.000
Farm size	.064	.027	.152	-.004	.002
Family size	-.089	.022	.090	-.001	.014
Soil fertility	.528	.304	.297	.000	.012
Access to climate information	.122	.033	.160	0.013	.001
Extension access	.154	-.098	087	.000	.019

(*) dy/dx is for discrete change of dummy variable from 0 to 1
Source; own survey data 2022

5. Interpretation of Regression Result

Sex of household head: From the result of multinomial logistic regression the coefficients of sex of household head are negative and statistically not significant for crop diversification and small scale irrigation, keeping other variables constant. Being female household head is better in practice of crop diversification and small scale irrigation as adaptation measure with ($p< 0.434$) and ($p<0.099$) respectively at 5% level of significance in the study area. Being male household head has positive and highly significant effect on adapting strategy like growing drought tolerant crop, for soil and water management and changing planting date to climate change impact with probability of $p<0.001$, $p<0.000$ and $p<0.000$ at 5% level of significance in the study site. Based on the result of marginal effect, even if the effects of sex on the probabilities of three of the strategies are negative and do not suggest important information, this could be an indication of the different implications of sex on adaptation measure. Given these situations, the result is justified with the possibility that being male and female farmer usually practice of adaptation measures which can be practiced to increase farm labour.

6. Education Level of Smallholder Farmer

The result of multinomial logistic regression shows that education had a positive effect on farmers' adaptation strategies and statistical significant in increasing adaptation strategies of crop diversification, growing drought tolerant crop, soil and water management, changing planting date and small scale irrigation with respective p-value $p<0.00$, $p<0.00$, $p<0.03$, $p<0.037$ and $p<0.029$. Education is highly significant in determining crop diversification and growing drought tolerant crop at 5% level of significance keeping other variables constant. Farmers who have more education level were more likely to adapt to climate change using crop diversification and growing drought tolerant crop practices than those who do have lower education level. This result might sources of the fact that education improves farmers' capacity of obtaining and analyzing new information about climate change and best adaptation practices that increases the probability of adapting to climate change. More specifically, it equipped farmers with knowledge of selecting appropriate crop diversification and drought tolerant variety. The result of from marginal effect shows that a unit increases in number of years of education could increase by 8.1% of the likelihood of adopting crop diversification and 1.8% practice of growing drought tolerant crop as adaptation measures at 5% level of significance.

Farm experience of household. In this study the coefficient of household farm experience is positive and statistical significant in determining adaptation measure such as crop diversification, growing drought tolerant crop, soil and water management, changing planting date and small scale irrigation with $p<0.00$, $p<0.001$, $p<0.00$, $p<0.009$ and $p<0.001$ respectively in the study site. The result of marginal effect shows a unit increases in number of years of farm experience could increase by 1.4% of the likelihood of adopting crop diversification, 5.7% of growing drought tolerant crop and 1.6% of soil and water management as adaptation measure at 5% level of significance. The number of years a farmer has spent cultivating crops on a farm is considered as his/her agricultural experience. Possessing many years of farming experience implies that one is better informed about climate variability and change in relation to crop produce, in the study areas; hence, experienced farmers are likely to use adaptation strategies which had reduced the effects of change and improved crop production.

Off-farm income:- off-farm income is significantly and positively affected crop diversification and the practice of soil and water management with $p<0.01$ and $P<0.03$ at 5% level of significance. The result of marginal effect shows a unit increases in number of years of farm experience could increase by 1.9% of the likelihood of adopting crop diversification. The higher farmers have off-farm income, the more likely they were to adapt climate change using crop diversification and soil and water management. Perhaps the reason is farmers have had an optional income source that help them withstand the impact of climate change and they are also capable of buying instruments for soil and water management.

Farm income:-coefficients of farm income from result of multinomial logistic regression is positive and statistical significant in determining the practice of adaptation measure such as crop diversification, growing drought tolerant crop, soil and water management and the use small scale irrigation at 5% level of significance with p-value 0.000, 0.007, 0.001 and 0.000 respectively. The result of marginal effect shows a unit increases in number of years of farm experience could increase by 1.4% of the likelihood of adopting crop diversification, 5% of growing drought tolerant crop at 5% level of significance. This implied that smallholder farmers who have higher farm income are more likely to adapt to the change in climate using these strategies. When the main source of income in farming increase, farmers tend to invest on productivity smoothing options such as using crop diversification and growing drought tolerant crop. Farm income enables the farmer to perceive and adapt to climate change by devoting higher cash for the purchase of seed and seedlings whenever the rain comes, buying a drought tolerant variety and apparatus for the use of soil and water management practice and irrigation at higher price.

Credit access: **-** the multinomial regression model revealed that farmers access to credit has a statistically significant positive effect on using of crop diversification, growing drought tolerant crop, soil and water management and using small scale irrigation at 5% level of significance, keeping another variable constant. Farmers who have access to credit are more likely to adapt climate change by practicing these adaptation strategies. a unit increase of access to credit could increase likelihood of crop diversification by 13.3%, growing drought tolerant crop by 9.3%, soil and water management by 23.2%. The result showed that having access to credit increases the propensity of farmers to apply the four adaptation strategies in response to climate change. This is due to the fact that access to affordable credit mitigates the financial limitation of the farmer and increases their ability to meet transaction costs associated with the various adaptation options they might want to take. It enables farmers to change their management practices in response to changing climatic factors and to buy varieties for crop diversification and drought tolerant varieties, tool/ instrument for soil and water management and small scale irrigation irrigation technologies like water pumps and other inputs to smoothening production and reduce the negative impact of climate change.

Market distance: **-** This variable is a continuous variable measured in kilometers from farmers home/farm to their market and coefficients of market distance is negative and statistically significant in determining crop diversification, growing drought tolerant crop, soil and water management and using small scale irrigation at 5% level of significance with p-value 0.000, 0.008, 0.001 and 0.000 respectively, keeping other variables constant. Market is an important determinant to buy input for crop diversification, growing drought tolerant crop, soil and water management practices and small scale irrigation tool to take adaptation measure to climate change, most probably reason the market serves as a means of exchanging information with other farmers. Moreover, access to inputs and transportation cost will be high for households far from a given market.

Farm size: - Landholding size highly significant and positively affected use of crop diversification, growing drought tolerant crop, soil and water management, changing planting date and small scale irrigation in response to climate change at 5% level of significance with all p-value 0.00, keeping other variables constant. The bigger the landholding, the more likely the farmer is to adopt crop diversification, growing drought tolerant crop, soil and water management, changing planting date and small scale irrigation. The possible reason is that farmers who have bigger farm size have an option to divide their farm into different enterprises. From results of marginal effect shows a unit increase in farm land by hectare could increase the likelihood of adopting crop diversification by 6.4%, growing drought tolerant crop by 2.7%, soil and water management by 1.5% and small scale irrigation by 0.02%.

Family size: -Family size also has statistically significant and positive effect on adaptation strategies to climate alter. A unit increase of number of family size, could increase likelihood of using crop diversification by 7.2%, growing drought tolerant by 0.3%, soil and water management by 0.04% and small scale irrigation by 0.02% as adaptation measure respectively, keeping other variables constant. Because household size can influence adaptation, due to the fact that its association with labor endowment.

Soil fertility:- soil fertility has statistically significant and positive effect on adaptation strategies to climate alter. From marginal effect result, a unit increase of number of soil fertility, could increase likelihood of using crop diversification by 5.2%, growing drought tolerant by 3%, soil and water management by 2.9% and small scale irrigation by 0.02% as adaptation measure respectively, than infertile soil keeping other variables constant. Fertile soil make easy farmers production during climate change adaptation measure such as crop diversification, growing drought tolerant crop and soil and water management.

Access to climate information: **-** Access to climate information significantly and positively affected using of drought tolerant varieties and using soil and water management at 5% level of significance. Farmers who have access to climate related information from different media like radio and television have a higher probability of awareness creation in using drought tolerant varieties and using soil and water management as an adaptation strategy to reverse climate change. Most likely, the reason is that access to climate information admits to perceive the change and choose appropriate strategies in response to climate change. Climate information notifies the condition of the existing climatic situations to enable the farmers to use alternative adaptation strategies like drought tolerant variety and soil and water management. From result of marginal effect unit increase climate information, could increase likelihood of using crop diversification by 12.2%, drought tolerant crop by 3.3%, and soil and water management by 16.1%.

Extension visit:- is also among the positive and significant explanatory variable in this model. A result from marginal effect, those who have access to farm extension service expected to have had unit increase of farm extension service could increase likelihood of using crop diversification adaption methods by 15.4%, growing drought tolerant crop by 8.7% and using small scale irrigation by 1.9% as compared to the farmers who have no access to farm extension service to handle climate change at 5% level of significance.

7. Conclusion

Multinomial logistic regression analysis was employed to analyze the factors influencing smallholder farmers' choice of adaptation strategies to climate change. The result from the multinomial logit regression analysis shows that sex, education, farm experience, off-farm income, credit access, market distance, farm size, family size, soil fertility, access to climate information and extension access have a significant influence on smallholder farmers' choice of adaptation strategies to climate change and age is not significant to climate change.

The strategy of crop diversification was positively affected by education, farm experience, off-farm income, credit access, farm size, family size, soil fertility, soil fertility, climate information and extension access, while sex and market distance negatively affect crop diversification. The unit increase in education, farm experience, off-farm income, credit access, farm size, family size, soil fertility, climate information and extension access will increase the practice of crop diversification likelihood of 6.8%, 8.1%, 3.4%, 1.7%, 14.1%, 6.4%, 5.3%, 1.2% and 1.5%. The unit increase in kilometer of market distance from farm to market could decrease likelihood of 1.8% use of crop diversification.

Growing drought tolerant crop was positively affected by education, farm experience, off-farm income, farm income, credit access, farm size, family size, soil fertility, access to climate information and extension access, while growing drought tolerant crop negatively affected by market distance. The unit increase in education, farm experience, farm income, credit access, farm size, family size, soil fertility and access to climate information could increase adoption of growing drought tolerant crop by 1.8%, 1.7%, 5.3%, 9.3%, 2.7%, 2.2%, 3.04% and 3.3%.

Soil and water management as climate change adaptation strategy was positively affected by farm experience, farm income, credit access, farm size, family size, soil fertility, access to climate information and extension access, while sex and market distance negatively affect soil and water management. The unit increase of farm experience, farm income, credit access, farm size, family size, soil fertility, access to climate information and extension access could increase likelihood of 1.6%, 23.2%, 15.2%, 9%, 29.7%, 16% and 8.7% practicing soil and water management.

The strategy of changing planting date positively affected by education, farm experience and farm size while sex negatively affect the strategy changing planting date. The unit increase of education, farm experience and climate access information could likelihood of adopting strategy of changing planting date 1.2%, 1.1% and 1.3%.

Small scale irrigation as climate change measure was positively affected by credit access, farm size and family size while small scale irrigation negatively affected by market distance. The unit increase of farm size and family size 0.02%, 1.4% and 1.2% could increase likelihood adopting small scale irrigation.

8. Policy Implication

The government and any concern body should give emphasis to address this issue of climatic change through paying greater focus. In the study area problem of food shortage is a common by the farmers of this Woreda especially when there is crop failure due to increased frequency of farm destruction, increased frequency of drought, off-seasonal rainfall and little rainfalls. Therefore, effort and strengthen the farmers' adaptive capacity to climate change through by providing different varieties for crop diversification and drought tolerant crop, introducing climate change problem and use of adaptation strategy into educational curriculum, organizing continuous climate related training center, providing modern tool for soil and water management and small scale irrigation and disseminating climate related information by local language through social media for farmers to enhance awareness has an important mechanism.

Due to the availability of different micro climate in the area and to improve the coverage and quality of climatic data local meteorology station should be established at least at woreda level. And it is important for monitoring climate data, developing climate forecasts and early warning for climatic hazards as early as possible.

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

Improving farmer's farm and off/non-farm income-earning opportunities is of great need for smallholder farmers. Thus, sufficient input supply which increases farm income and creation of off/non-farm employment opportunities in the rural areas can be underlined as a policy option in the reduction of the negative impacts of climate change.

Improve farmers' access to affordable credit and support the growth and development of credit institutions and it is important to consider its accessibility to farmers nearby their locality and of other income generating activities to increase their ability and flexibility in response to climate change.

9. Recommendation

interventions aimed at mitigating the adverse effect of climate alter and variability need to focus on supporting farmers to intensively use and expand the existing adaptation strategies in the way match with agro-ecology: by using crop diversification, growing drought tolerant crop, soil and water management, changing planting date and small scale irrigation practices.

Electing model farmers of adopter and making them to share their experiences to the non-adopter of farmers is very important to promote adaptation in the community. This encourages Promotion of a given adaptation strategies should consider the agro-ecological setting of the area special consideration for successful use of adaptation measures by smallholder farmers.

Promoting farm-level adaptation need to emphasize on the crucial role of providing information on better production techniques and enhancing farmers' awareness on climate change (through extension) and creating the financial means through affordable credit schemes to enable farmers to use different adaptation measures to climate change.

Including climate change related agenda in education curriculum will increase the continuous knowledge about the use of adaptation strategy as a culture because 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.

Generally, future policy should focus on awareness creation on climate change through different sources such as media and extension, facilitating the availability of credit especially to adaptation technologies, enhancing research on use of new crop varieties that are more suited to drier conditions, improving farmers farm and off-farm income earning opportunities, improving their literacy status, and improving their access to credit. Moreover, encouraging informal social net-works and environmental settings enhance the adaptive capacity of smallholder farmers.

Information on appropriate adaptive measures should be made available to the entire community. As part of this effort, communication between policymakers, research institution, Universities, and the media, among other actors, should be strengthened in order to ensure accurate information is available and widely disseminated.

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