Determinants of farmers' preference for adaptation strategies to climate change: evidence from north shoa zone of Amhara region Ethiopia

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May 2011

Determinants of Farmers' Preference for Adaptation Strategies to Climate Change:

Evidence from North Shoa Zone of Amhara Region

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Abstract

Studies on climate change adaptation recognize the importance of agro-ecology based research for designing context-specific policies and programs to climate change. This study, therefore, applied a case-study approach to examine farmers' preference for climate change adaptation strategies and the factors deriving their preference. Thus, households' preference for five types of climate change adaptation strategies (multiple cropping, livestock, soil conservation, irrigation, and changing planting dates) is identified and the determinants of the preference are analyzed using Rank-Ordered Logit Model. The result shows that multiple cropping is the most preferred and frequently applied adaptation strategy to climate change, while livestock production is the least. The result also indicates that gender, age, farming experience and education level of the household head, household size, and farm and nonfarm income; farm size and farm distance to homestead; agricultural extension services and access to climate forecast information; farmers' perceptions on long-term average temperature and rainfall affect farmers' preference for the climate change adaptation strategies. Thus, policies and programs with the aim of reducing climate change impacts through adaptation need to consider important roles of these factors. The main barriers to climate change adaptation are lack of information or knowledge, shortage of money, shortage of land, and unsuitability of land and poor potential for irrigation. Although adaptation is one of the policy options for reducing the negative impacts of climate change, it is challenged by these constraints. Therefore, promoting investments and strengthening efforts to address these constraints is suggested to enhance farmers' adaptation capacity and thus adaptation to climate change.

Keywords: Climate change; Adaptation preference; Perception; Rank-Ordered Logit Model

1. Introduction

The Ethiopian economy is dominated by subsistence agriculture which is characterized by small-scale farming and livestock husbandry. The sector employs 85 percent of the country's labor force and accounts for 60 percent of all exports. Approximately 80 percent of households live in rural areas and are dependent on local agriculture to meet their food needs (WFP, 2009). Recent report of MoFED showed that contribution of the sector to the overall economy is estimated to be 41.6 percent of the GDP (MoFED, 2010).

Agriculture plays a significant and decisive role in the social and economic development of the country. However, owing to natural and man-made causes the country has not properly benefited from its abundant natural resources conducive to agricultural development, and consequently failed to register the desired economic development that would enable its people pull out of the quagmires of poverty. The major impediments to agricultural development are the predominance of subsistence agriculture and lack of more business/market-oriented agriculture; adverse climatic changes; failure to use agricultural land according to appropriate land use management plan and resource base; limitation in information base; lack of supply and dissemination of appropriate technology; failure to integrate relevant activities; and lack of adequate implementation capacity (MoFED, 2006).

Ethiopia provides a good example of the influence of climate change on a developing country's economy. The country's economy is sensitive to climate variability, particularly variations in rainfall (USAID, 2007). In addition to the nature-dependent agricultural sector of the economy, the country's geographical location and topography in combination with low adaptive capacity can cause a high vulnerability to adverse impacts of climate change. Historically, Ethiopia has been suffering from natural catastrophes and is prone to extreme weather events. Rainfall in Ethiopia is highly erratic, and most rain falls intensively, often as convective storms, with very high rainfall intensity and extreme spatial and temporal variability.

It is indicated in some literatures that Ethiopian farmers have already perceived the climate change and started taking different adaptation measures. It is also shown that the most preferred adaptation strategy by farmers is mostly applied in combination with other strategies and not alone (Hassan & Nhemachena, 2008). There are also farmers who are not taking adaptation measures (Deressa et al, 2009). It is, therefore, vital to identify both the generic and climate-specific elements of farmers' adaptation behavior and preferences in order to help responses not only to the current but also to the future changes in climate and the possible impacts. Better understanding of farmers' preferences for adaptation strategies and the factors deriving their choices is important to inform policy for future adaptation of the agricultural sector to climate change (Nhemachena & Hassan, 2007).

Furthermore, climate change adaptation policy and program design needs to consider the specific characteristics of every places and community. Deressa et al (2009) indicated that policies focusing on adaptation to climate change have to aim at providing adaptation technologies through agro-ecology based research. That means, one-size-fits-all recommendations are inappropriate given the differences in agroecologies and other factors among farmers in different parts or areas of the country. Beside this, the performance and application of different adaptation technologies or methods is location specific. Therefore, programs aimed at promoting adaptation technologies as part of a climate change adaptation strategy should take such important differences into account (Kato et al, 2009). As cited by Seo & Mendelsohn (2007), understanding farmers' adaptation behavior is an important goal in itself to assist planning by policymakers and private individuals (Smith, 1997; Smit et al., 2000; Smit and Pilifosova, 2001). Understanding adaptation is also highly important if one is interested in quantifying the impacts of climate change (Mendelsohn et al, 1994).

Generally, farmers in different areas or agricultural zones would possibly have unequal propensity and capacity to climate change impacts and adaptation processes. As it is indicated by Fussel (2007), tailoring adaptation practices to specific societies or communities according to their context may make it possible to offset the adverse impacts of climate change. IPPC (2007) also showed that the capacity to adapt to climate change is unequal across and within societies. There are individuals and groups within all societies that have insufficient capacity to adapt to climate change. Measures at local or micro level are important and feasible in the reduction of climate change impact on farmers in a certain area.

However, enough studies specific to each agroecological zones of Ethiopia have not been made though there are some efforts to examine farmers' choices of adaptation strategies to climate change and the respective determinants. A notable study is the one carried out by Deressa et al (2009) in the Nile Basin of Ethiopia. There is, therefore, a need for researches at household and/or farm level which are very essential to know micro level farm and farmers' characteristics and thus help design appropriate policies and strategies in that local context. Because policies and strategies at micro and household level regarding climate change adaptation are equally important with the macroeconomic development policies and strategies.

Shoa Robit and the surrounding area in the North Shoa zone of the Amhara region is among those areas which needs similar studies specifically to the area. Because the area has its own specific characteristics interms of exposition to climate change. Its agro ecology is kola, characterized by hot temperature and erratic rainfall. The area (especially the agriculture) is seriously and successively affected by changing climatic condition and its extremes. Besides, there are two rivers (Shoa Robit and Kobo River) in the area which were used for inappropriate purposes such as waste depository, and to feed animals, wash clothes and bodies for longer periods of times. As time goes on, the people started to use the rivers as recreation sites, to irrigate their crops and vegetables. Nowadays, the rivers are decreasing from time to time in amount and losing their capacity of serving the people which sometimes resulted in societal conflict and challenges.

Therefore, this research would contribute to the issue by identifying and analyzing the determinants of farmers' preference for adaptation strategies to the impacts of climate change in this area. It also examined farmers' preferences for adaptation strategies as well as barriers to adaptation. The study would also contribute to the existing research on climate change adaptation and modeling of preferences.

2. Objectives

The main objective of the research is to determine factors that influence farmers' preference for a particular adaptation strategy to the impacts of climate change. The research has the following specific objectives:

- Knowing farmers' preference for different adaptation strategies to climate change and the effects of determinants of this preference.
- Identifying micro-level policy recommendations and intervention areas.

3. Study Area and Data

The study area for this research is Shoa Robit town and the surroundings areas in the North Shoa Zone of the Amhara National Regional State. It is around 220 km far away from the capital city of Ethiopia, Addis Ababa. The area is characterized by Kolla[1] agro-ecology and different levels of temperature and erratic rainfall among different production periods or seasons. Mixed farming is a commonly practiced farming system (rain-fed and irrigated crops, perennial /annual crops, livestock). The administration's report (2008) indicated that the area has an estimated dry farm land of 2739.2 hectares and irrigable land of 1242.5 hectares. Moreover, there are two rivers Shoa Robit River and Kobo River which serve different purposes for both the Shoa Robit town people and the surrounding farmers. The administration includes 9 Kebeles[2] of which the first 4 Kebeles are in the urban area and the remaining 5 Kebeles in rural areas. The total population in the study area is 55,270 people.

This research has used both primary and secondary data collected in the production year 2009/2010. Among the 9 Kebeles in the study area, seven of them (5 rural and 2 urban Kebeles) are selected purposively by considering the different environmental and socioeconomic characteristics of the areas. Next, a total of 238 households were selected randomly from the selected Kebeles. However, the final dataset includes only responses of 225 households because 13 households did not give full and reliable responses to the questions and thus omitted. Finally, primary data on farmers' preference for climate change adaptation strategies, different attributes of the households, their farms, institutional factors and climate perception variables is collected using questionnaire and face-to-face interview with the household head. The research has also used secondary data on weather conditions (temperature and precipitation level) of the study area which is collected from the National Meteorological Agency of Ethiopia.

4. Empirical Model and Variables

The analytical model used for this research is the Rank-Ordered Logit Model (ROL model hereafter). The ROL model takes advantage of the added information if respondents are asked to rank each alternative instead of the most preferred one. Beggs et al (1981) as cited by Fok et al (2010), and Padilla et al (2003) noted that more information per respondent and thus an efficiency can be obtained in estimating parameters if we ask the farmers for a ranking of the whole set of alternatives available to them instead of listing their preferred choices. Therefore, in this research the ROL model is used by taking only case-specific explanatory variables when all alternatives are fully ranked without ties[3].

The research assumed that based on their detail knowledge of their farming environment, agricultural problems and past experiences, farmers can state their preferences for the alternative adaptation strategies to climate change in line with their utility maximization objective under different constraints and resource endowments. Hence, the farmers are presented with five randomly permutated list of possible adaptation

[1] *"Kolla" is lowland that ranges, 500–1500 m above sea level*

[2] *"Kebele" refers to the smallest administrational unit.*

[3] *"Ties" are situations when the same ranks are given for different alternatives.*

strategies to climate change and interviewed systematically to capture the order of their preferences for the whole set of alternative adaptation strategies (from the most preferred to the least preferred). This is done by treating the assignment of each rank for each alternative as a choice process itself and then separating rank orderings into series of choices.

The functional relationship is, therefore, given by

$$ASP = f(H, F, I, C) \quad (1)$$

where, ASP refers to Adaptation Strategy Preferences (rank-orderings) of farmers; H to household characteristics; F to farm characteristics; I to institutional factors and C refers to climate perception variables.

The empirical literature review and the researcher's personal observation from the study area have been used in selecting adaptation options. Therefore, the following five alternative adaptation strategies are included in the analysis: Multiple Cropping (MC), using different and new crop varieties; Livestock Production (LI); Soil Conservation (SC); Irrigation Development (IR); and Changing Planting Dates (CD), early and late planting.

The adaptation measures that farmers applied may be profit driven, rather than climate change driven. Despite this missing link, the study assumes that the farmers' actions are driven by climatic factors.

The study uses the random utility framework to represent the preferences of the households. The random utility framework is a widely applied framework to situations where individuals are asked to state and rank their preferences for alternative choice set where the utility of each alternative is a function of observed characteristics plus an additive error term (Verbeek, 2008; McFadden, 1974). The utilities for each farmer are represented by U_{i1}. … U_{iJ} where i represents the individual farmers and j refers to the adaptation method/s selected by them. It is assumed that the respondent makes a systematic choice and therefore knows all benefits that could be derived from the adaptation strategies. The random utilities for individual i are, thus, expressed as

$$U_{ij} = V_{ij} + \varepsilon_{ij} \quad (2)$$

where $\mathbf{V_{ij}}$ refers to the systematic component of the utility and $\boldsymbol{\varepsilon_{ij}}$ is the random component of the utility.

The systematic part of the utility is going to be determined by the observed individual characteristics, and is modeled as

$$V_{ij} = X_i'\beta_j \quad \mathbf{(3)}$$

where, X_i is an m-dimensional vector of characteristics of individual i (that is case-specific explanatory variables) and β_j is an m-dimensional parameter vector specific to alternative j.

From the ranking of the farmers, the response of respondent i is denoted by the vector

$$y_i = (y_{i1} \cdots y_{ij})' \quad (4)$$

where y_{ij} now denotes the rank that individual i assigns to item j.

For analysis purpose the next equivalent notation is used

$$r_i = (r_{i1}, \dots, r_{ij})' \quad (5)$$

where r_{ij} is the item number that received rank j by individual i.

An observed ranking by a respondent is an implication of the complete ordering of the underlying utilities that could be derived from the respective method. A farmer prefers an adaptation method with a higher benefit over an option with a lower benefit. If we observe a full ranking r_i of the given alternatives, it implies that $U_{iri1} > U_{iri2} > \cdots > U_{irij}$. Assuming that all ε_{ij}'s are independent and follow type I extreme value distribution, we get the ROL model. Hence, the probability of observing a particular ranking r_i will be

$$\mathbf{Prob}[\mathbf{r_i};\ \boldsymbol{\beta}] = \mathbf{Pr}[\mathbf{U_{iri1}} > \mathbf{U_{iri2}} > \dots > \mathbf{U_{iriJ}}] = \prod_{j=1}^{J-1} \frac{\exp(V_{irij})}{\sum_{l=j}^{J} \exp(V_{iri1})} \quad (6)$$

By extending the above logic to the ranking of the adaptation strategies by farmers, the probability of the rank-ordering is expressed as:

$$Prob(Y_1 = MC, Y_2 = LI, Y_3 = SC, Y_4 = IR|X) = Prob\ (Y_1 = MC|X) \times Prob\ (Y_2 = LI|X, Y_1 = MC) \times Prob\ (Y_3 = SC|X, Y_1 = MC, Y_2 = LI) \times Prob\ (Y_4 = IR|X, Y_1 = MC, Y_2 = LI, Y_3 = SC) \quad (7)$$

where MC, LI, SC, IR represent Multiple Cropping, Livestock, Soil Conservation and Irrigation Development respectively and Y_1, Y_2, Y_3 and Y_4 refer to the first, second, third and fourth choices, respectively.The last choice is not taken in to account because if the first four choices are known, the last choice is implied.

The probability of multiple cropping being selected from a set of five alternative adaptation strategies is

$$\mathbf{Prob(Y_1 = MC|X)} = \frac{\exp(X\beta_{MC|b})}{\sum_{j=1}^{J} \exp(X\beta_{j|b})} \quad (8)$$

where X contains case-specific variables, b is the base category (in this case the selection of base category is arbitrary), βk,m|b is the effect of the X_K on the log odds of choosing alternative m over the base category, and βk,b|b=0 for all explanatory variables k.

The probability of livestock being selected given a choice set that excludes multiple cropping requires that we subtract exp ($X\beta_{MC|b}$), and then it will be

$$\mathbf{Prob(Y_2 = LI|X, Y_1 = MC)} = \frac{\exp(X\beta_{LI|b})}{\left\{\sum_{j=1}^{J} \exp(X\beta_{j|b})\right\} - \exp(X\beta_{MC|b})} \quad (9)$$

Similarly, the probability of soil conservation being selected from a choice set that excludes MC and LI requires that we subtract exp ($X\beta_{MC|b}$) and exp ($X\beta_{LI|b}$) from the denominator

$$\mathbf{Prob(Y_3 = SC|X, Y_1 = MC, Y_2 = LI)} = \frac{\exp(X\beta_{SC|b})}{\left\{\sum_{j=1}^{J} \exp(X\beta_{j|b})\right\} - \exp(X\beta_{MC|b}) - \exp(X\beta_{LI|b})} \quad (10)$$

In a similar way, the probability of irrigation being selected from a choice set that excludes MC, LI and SC again requires that we subtract exp ($X\beta_{MC|b}$), exp ($X\beta_{LI|b}$) and exp ($X\beta_{SC|b}$) from the denominator:

$$\mathbf{Prob\ (Y_4 = IR|X, Y_1 = MC, Y_2 = LI, Y_3 = SC)} = \frac{\exp(X\beta_{IR|b})}{\left\{\sum_{j=1}^{J} \exp(X\beta_{j|b})\right\} - \exp(X\beta_{MC|b}) - \exp(X\beta_{LI|b}) - \exp(X\beta_{SC|b})} \quad (11)$$

Moreover, unbiased and consistent parameter estimates of the ROL model requires the independence of irrelevant alternatives which implies the independent and homoscedastic disturbance terms. Therefore, the researcher assumes the Independence of Irrelevant Alternatives (IIA).

Finally, the model is fitted by maximizing the probability of observing the rank orders that were observed among all cases using the Maximum Likelihood Estimation (MLE) approach. Interpretations in this study relied on the change in predicted probabilities for discrete changes in the explanatory variables because change in predicted probabilities for discrete changes in the independent variables is more effective and preferred method of interpretation that can be used for both continuous and dummy independent variables. The discrete change in the predicted probability of a certain outcome for a change in X_K from the start value say, X_S, to the end value say to, X_E,

$$\frac{\Delta \Pr(y=m|X)}{\Delta X_K} = \Pr(y = m|X, X_K = X_E) - \Pr(y = m|X, X_K = X_S) \quad (12)$$

where $Pr(y = m|X, X_K)$ is the probability that y = m given X, by assigning specific value to X_K.

The change in the probability is interpreted as when X_K changes from X_S to X_E, the predicted probability of outcome m changes by $\Delta \Pr(y = m|X)/\Delta X_K$, holding all other variables constant. Furthermore, to understand the nature of the overall preference of the households for the five adaptation strategies, the odds values are used.

The dependent variable for the ROL model is the rankings of farmers for the five alternative adaptation strategies. The identification of the model's explanatory variables is based on literature and availability of data. Thus, the explanatory variables identified are household characteristics such as age, education level and gender of the household head, household size, farming experience, farm and non-farm income, television and/or radio ownership, and living area of the farmers; farm characteristics such as farm size, distance to input market, distance to output market, and farm distance to homestead; institutional factors such as provision of extension services by experts, farmer-to-farmer extension services, credit services, access to climate forecast information, knowing others who perceived and adapted to climate change, and training on agriculture; climate perception variables such as farmers' perception of long-term[4] temperature and rainfall.

5. Results and Discussions

A. Barriers to Adaptation

The constraints/barriers to adapt to climate change faced by the farmers in the study area are lack of information or knowledge (34.55%), shortage of money (23.95%), shortage of land (20.4%), unsuitability of land and poor potential for irrigation (11.5%), shortage of labor (5.6%) and others (4%): (Figure 1). The study showed that lack of information /knowledge is the main constraint to adaptation. This could be a manifestation of poor information system of the concerned bodies, poor training or extension services for the farmers. It can also imply weak research and development efforts on suitable and new agricultural practices.

Since money is the medium households commonly use to make purchase of the necessary inputs and other transactions, it is expected that their adaptive capacity to climate change is limited by shortage of money. Getting credit is not an easy task for the farmers. One reason is farmers could not produce collateral to get credit. Some mentioned that they don't want to borrow money for the simple reason that they fear borrowing and servicing of the borrowed money.

Additionally, shortage of land is the third constraint that challenges the farmers. This constraint includes not only shortage in terms of size of land but also the fertility of the land, as mentioned by the farmers. They explained that their currently owned land is poor in its fertility and is losing its capacity from time to time. Increasing in the number of population in general and households' size in particular would force households to fragment and overexploit their limited farm land. This situation could limit their capacity to exercise diverse adaptation measures to climate change. Moreover, some lands are not suitable to undertake adaptation measures such as soil and water conservation, and tree planting. Farmers cannot also grow any kind of crop they want as it is limited by the nature of their land. Lack of land suitable for irrigation is a big constraint to undertake irrigation activities. However, even those farmers who have their own irrigable land are facing difficulty to undertake irrigation due to lack of water. As mentioned previously, there are two rivers in the study area. Few years ago, large number of farmers started using the rivers for different purposes particularly for irrigation. This in combination with the changing climatic conditions made the rivers unable to serve the needs of the farmers. Shortage of labor is also a constraint for 5.6% of the households. Others constraints include lack of fodder, animals' death, unavailability of technologies, unwillingness to take measures and unable to adapt due to for instance age.

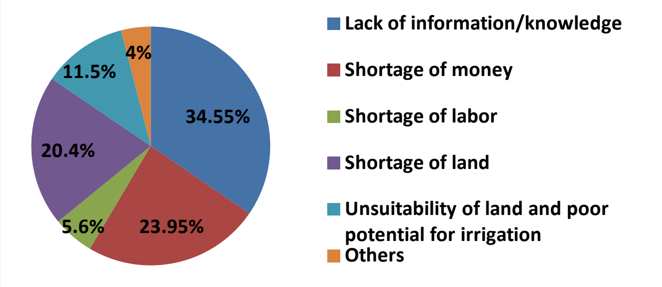

Figure 1: Adaptation Constraints

B. Model Specification and tests

The rank-ordered data on the farmers' preferences for five adaptation strategies data is fitted using the rank-ordered logistic regression. The data is a cross-sectional which is collected from a sample of 225 households. The working data set for the analysis is consisted of a separate record for each adaptation strategy for each respondent, for a total of 1125 observations (that means 225 respondents × 5 alternatives). The estimation is conducted by normalizing multiple cropping, as the base category.

Hendry approach is followed to arrive at the final model. Different statistical tests and fitness measures have been conducted using Overall LR^2, the Bayesian Information Criteria (BIC), Variance Inflation Factor (VIF) and the Wald Test methods. In the initial run, all of the variables identified were included to the model. Then, by excluding those highly insignificant variables and those expected to bring multicollinearity problem one-by-one, different models were estimated and each has been checked for fitness. Hence, variables such as living area of the farmers, input market distance, output market distance, ownership of television and/ or radio, knowing others who perceived and adapted to climate change and training on agriculture are dropped. Moreover, a variable "market distance" (average of both input and output market distances) is included and the final model is fitted. Summary statistics of the explanatory variables included in the model is given in Table 2.

[4] *Long-term in this research is for 20 years and above.*

Table 1: Wald test results for each explanatory variable at 5%

No	Variables	Chi2 (4)	Prob> chi2	Evidence
1	Male	19.14	0.0007	Against Ho
2	Age of household head	21.12	0.0003	Against Ho
3	Education level	33.24	0.0000	Against Ho
4	Farming experience	28.66	0.0000	Against Ho
5	Household size	24.76	0.0001	Against Ho
6	Farm size	17.54	0.0015	Against Ho
7	Farm distance to homestead	42.88	0.0000	Against Ho
8	Market distance	4.050	0.3987	For Ho
9	Farm income	14.42	0.0061	Against Ho
10	Nonfarm income	15.58	0.0036	Against Ho
11	Extension by experts	19.78	0.0006	Against Ho
12	Farmer-to-farmer extension	6.590	0.1591	For Ho
13	Credit access	3.880	0.4226	For Ho
14	Climate forecast	12.76	0.0125	Against Ho
15	Perceived temperature	41.11	0.0000	Against Ho
16	Perceived rainfall	12.02	0.0172	Against Ho

The final model was also tested for multicollinearity using the VIF and all VIF values for all explanatory variables are less than 7 and the mean VIF is 2.08 where for most of the variables, the VIF is between 1 and 2. This indicates that multicollinearity is not a serious problem in the model. Parameterization of the model by excluding one category also helps to avoid exact multicollinearity. Furthermore, the model was tested for Independence of Irrelevant Alternatives (IIA) using the Hausman-McFadden test and no evidence is found to reject the IIA assumption at 5% significance level. This suggests that the specified ROL model is appropriate to modeling the farmers' preferences for climate change adaptation strategies.

The Wald test results for each explanatory variable included in the final model are given in Table 1. Among the 16 explanatory variables included in the final model, only three of them are found to be statistically insignificant to influence the dependent variable. They are market distance, farmer-to-farmer extension and credit access. The remaining 13 variables have statistically significant effect on the farmers' preferences for adaptation strategies to climate change at 5% level of significance.

Finally, to check the efficiency gain from ranking data, two models are estimated: the first is based on the full ranked data and the second is using only the most preferred alternative. Then, Hausman-McFadden specification test is conducted. It fails to reject the null hypothesis which states that estimates do not change systematically (because P > chi2 = 1.0000). Therefore, exclusion of the four rankings is inefficient even if it doesn't lead to inconsistency. As a result, the ROL model with full ranking is more appropriate since its estimates are both consistent and efficient.

C. Overall Preference for the Adaptation Strategies

The ROL model with constant only ($V_{ij} = \beta_j$) is estimated to see the overall preferences of the households for the adaptation strategies. Table 3 presents estimates of the β_j (constants), the exponent of the coefficients and predicted probabilities for each adaptation strategy at the means of all explanatory variables. The odds are interpreted with reference to the base category. As we see, the constant parameter for multiple cropping is zero because multiple cropping is used as a base category in our estimation and its coefficient necessarily equals to zero. The Wald chi-square statistic for the model with a constant term only is 303.48 with a p-value of 0.0000, which means that the farmers in the area, in general, have statistically significant different preferences for the five adaptation strategies.

The result indicates that on average multiple cropping is the most preferred adaptation strategy while livestock is the least preferred adaptation strategy because its odds is the smallest (that is 0.1412) among the five odds. The second

Table 2: Summary statistics of the explanatory variables

No	Variables	Description	Min	Max	Mean	S.D.
1	Gender of household head	Dummy, 1 if male and 0 otherwise	0.00	1.00	0.88	0.32
2	Age of the household head	Continuous	22.00	68.00	41.12	10.42
3	Education level	Continuous	0.00	12.00	3.31	3.60
4	Farming experience	Continuous	5.00	54.00	24.78	10.70
5	Household size	Continuous	2.00	10.00	5.20	1.92
6	Farm size in hectares	Continuous	0.25	2.75	1.21	0.51
7	Farm distance to home in KMs	Continuous	0.25	17.00	5.05	3.88
8	Market distance In kilometers	Continuous	0.48	12.75	4.72	2.72
9	Farm income in birr 1000	Continuous	0.50	52.78	14.85	10.33
10	Nonfarm income in birr 1000	Continuous	0.00	40.00	1.69	4.01
11	Extension by experts	Dummy, 1if received and 0 otherwise	0.00	1.00	0.75	0.43
12	Farmer-to-farmer extension	Dummy, 1 if there is and 0 otherwise	0.00	1.00	0.89	0.31
13	Credit access	Dummy, 1if there is and 0 otherwise	0.00	1.00	0.39	0.49
14	Climate forecast	Dummy, 1 if received and 0 otherwise	0.00	1.00	0.32	0.47
15	Perceived temperature	Dummy, 1if perceived and 0 otherwise	0.00	1.00	0.68	0.47
16	Perceived rainfall	Dummy,1if perceived and 0 otherwise	0.00	1.00	0.92	0.26

most preferred adaptation strategy is soil conservation measure followed by irrigation and then changing planting dates.

Next, let us look at the probability of each adaptation strategy being preferred first at the means of all explanatory variables. As it can be see from Table 3, an "average" household in the sample has a probability of 0.36 of ranking multiple cropping as the adaptation strategy that he/she most highly prefers while, it has a probability of 0.30 of ranking soil conservation first. Similarly, the probabilities of ranking irrigation, changing planting dates and livestock first are 0.18, 0.14 and 0.02, respectively. Overall, multiple cropping is the most preferred adaptation strategy followed by soil conservation while, livestock is the least preferred strategy in the study area.

D. Effects of the Independent Variables

The estimated coefficients of the ROL model, along with significance levels, are presented in Table 4. The model's likelihood ratio statistics (LR chi2(68) = 604.38 and P>chi2=0.0000) suggests that the model has a strong explanatory power. Since the parameter estimates of the ROL model provide only the direction of the effect of the independent variables on the dependent variable, the discrete changes in the probabilities is used to explore the effects of the independent variables on the farmers' preference for a particular adaptation strategy. The estimation of predicted probabilities based on discrete changes in the independent variables is more convenient and straightforward in the case of dummy independent variables, since they change from 0 to 1. As Long & Freese (2006) stated, for binary variables, the discrete change from 0 to 1 is the only appropriate quantity for interpretation. For the continuous independent variables, estimations of predicted probabilities are made for two types of changes in the independent variable: 1) for a unit change in the variable centered on its mean, and 2) for a standard deviation change in that variable centered on its mean. For the sake of simplicity, the values of the remaining independent variables are held constant at their means during interpretation. Given these conditions, interpretations are made for all significant variables. In the ROL model, the predicted probabilities are for an alternative being ranked first. That means the estimated probabilities represent the probabilities of ranking first each adaptation strategy.

I. Gender of the household head

Gender of the household head is one of the significant variables that affect the overall preference of farmers for the adaptation strategies. As we can see from Table 5, male-headed households have probability of preferring soil conservation as the most preferred adaptation strategy 16.6% higher than female-headed households and for irrigation 6.6% higher than female-headed households. On the other hand, the probability of ranking changing planting dates as their most preferred adaptation strategy is 12.6% lower for male headed households than female-headed ones. Similarly, the predicted probabilities of ranking multiple cropping and livestock first are 7.7% and 3.0% lower for male-headed households.

Overall, male-headed households have greater preferences for soil conservation and irrigation adaptation measures to climate change than female-headed households. Since soil conservation and irrigation development relative to the other adaptation strategies require better skills and information on technologies to undertake them to adapt to climate change, it is more likely that male-headed households have more preference for these measures than the female counterparts. This is in line with the argument that male-headed households are more likely to get information about new technologies than female-headed households (Asfaw & Admassie, 2004). Moreover, female-headed households are more likely than male-headed households to exercise adaptation methods which are common and known by almost all farmers, such as changing planting dates and crop production.

II. Age of the household head

Adaptation strategy preference to climate change is also affected by age of the household head. For instance, a one year (or by a standard deviation, around 10 years) increase in the age of the household head that is centered on its mean results in a 2.2% (or 22.7%) increase in the probability of ranking soil conservation first, 0.02% (or 0.2%) increase in the probability of ranking livestock first and 0.5% (or 5.5%) increase in the probability of changing planting dates, respectively. Also, an increase in the age of the household by one year (or by a standard deviation) that is centered on its mean decreases the probabilities of ranking multiple cropping and irrigation first by 0.5% (or 5%) and 1.3% (or 13.5%), respectively.

As indicated by Hassan & Nhemachena (2008) the influence of age on adaptation choices has been mixed in the literature. Some studies found that age had no influence on a farmer's decision to participate in forest and soil and water management activities while others found that age is significantly and negatively related to farmers' decisions to adopt. However, Bayard et al (2007) found that age is positively related to the adoption of conservation measures.

Even if the effects of age on the probabilities of two of the measures are negative and do not suggest important information, this could be an indication of the different implications of age and farming experience on adaptation preference. Given these situations, the result is justified with the possibility that old-aged farmers usually prefer adaptation measures which can be practiced with the limited resources at their disposal so as to smooth the household's consumption.

***Table 3: Odds of overall ranking* and predicted probabilities at the means of all explanatory variables**

No	Adaptation Strategy	Coefficient	Exp(b)	Probability
1	Livestock	-1.95734	0.1412	0.02275157
2	Soil conservation	-0.06895	0.9334	0.29519317
3	Irrigation	-0.47168	0.6240	0.18354297
4	Changing planting dates	-0.63836	0.5282	0.1397042
5	Multiple cropping	0	1	0.3588081
		LR chi2(4) = 303.48	Prob > chi2 = 0.0000	

As a result, it is likely that old-aged farmers prefer to practice soil conservation on their limited land and grow their common crops by changing planting dates. They also prefer to tend livestock with small efforts than the younger farmers. In contrast to this, younger farmers are better to adopt improved technologies or methods than older ones without fear of risks and future uncertainties. Younger farmers also have better energy to devote, better access to new information, and thus more likely to grow varieties of crops and develop irrigation. This is inline with the result that young farmers are more likely to face the risks associated with innovations (uncertainty in yield and unfamiliarity in technology) and to adopt them than their old counterparts (Asfaw & Admassie, 2004).

III. Education level of the household head

The effect of education is largest on the probability of multiple cropping where its probability to selected first increases by 4.7% for a one year increase in education centered on its mean and by 16.7% for a standard deviation increase in years of education. It was expected that farmers with higher levels of education are more likely to adapt better to climate change using various methods because a farmer who has more years of education is more likely to adopt improved methods and expected to be more efficient to understand and obtain new technologies than less-educated people.

Even though unexpected result is found, this possibility can be explained from various angles in the context of the study area. The result points out that education plays a great role in farmers' decision to specialize or work more intensively on specific activities. Additionally, it is common to see when an educated farmer is working for jobs outside agriculture in combination with the commonly practiced farming system, which is crop production. On the other hand, more educated farmers are more likely to get information on new crop varieties that would make them profitable with in the changing climatic conditions. They are, therefore, more likely to specialize on producing such crops and utilize their limited farm land effectively instead of moving and looking for other alternatives such as irrigable lands.

In addition to this, crop production is highly practiced in the area in both dryland and irrigable land. Nowadays, farmers started growing a more profitable and recently introduced crop to the area called "*Masho*[5]". It is heat-tolerant crop and can grow with little rain. Since farmers fear future uncertainties/ risks and are less confident to this new crop variety, education could play great role here. From the result, education has positive and significant impact on multiple cropping. This is possibly due to educated farmers who have better information about that crop and nature of the climate prefer to grow that crop intensively with less hesitation than the less-educated farmers. More educated farmers are more likely to have additional off-farm job to sustain consumption in case the crop fails. Moreover, they could have better information on how the crop is growing, in which environment it can grow, what the future climate likely to be than the less educated farmer.

IV. Farming experience

Farming experience of farmers increases the likelihoods of preferring irrigation, multiple cropping, soil conservation and changing planting dates as the most preferred adaptation strategies to climate change. For instance, an increase in farming experience by one year centered on the mean increases the probabilities of selecting multiple cropping, irrigation, soil conservation and changing planting dates first by 1%, 1.2%, 3.0% and 0.3%, respectively, while the probability of livestock decreases by 0.2%. Increase in farming experience has the largest positive effect on the probability of preferring soil conservation followed by irrigation and the smallest effect on livestock. That means, more experienced farmers are more likely to use soil conservation, irrigation, changing planting dates and multiple cropping to adapt to climate change because the more experienced farmers are, the more likely they have better information on changes in climatic conditions and knowledge of crop practices.

The result shows that farming experience has opposite effect with age of the household head for three of the adaptation strategies. Even if age of farmers is a significant factor, the directions of some of its effects do not suggest relevant particular pattern. Hassan & Nhemachena (2008) found that it is experience rather than age that matters for adapting to climate change. They also found that farming experience increases the probability of uptake of all adaptation options while age of the farmer did not seem to be of significant in influencing adaptation.

V. Household size

Household size is another determinant where an increase in the household size by one person centered on its mean results in increase in the probabilities of preferring multiple cropping, livestock and changing planting dates by 0.7%, 1.1% and 1.2%, respectively.

Therefore, increase in household size increases the probability of adapting to climate using multiple cropping, livestock and changing planting dates. This result suggests that these strategies are labor-intensive which is more likely to happen in Ethiopia's agriculture. Assuming that households with large family size have a higher labour endowment, families with more household size can rely on their own labor for the most important activities of multiple cropping that is the field operation. Families with larger household size are also more likely to rear livestock because of availability of labor to tend the animals. This result is also in line with the argument that multiple cropping and mixed farming systems are more labor intensive (Hassan & Nhemachena, 2008).

VI. Farm size of the household

Households' farm size is also a significant factor that affects farmers' preferences for the adaptation strategies to climate change. In a similar way, an increase in farm size by 1 hectare (or by 1 standard deviation) that is centered around its mean increases the likelihood of selecting multiple cropping as the most preferred adaptation strategy by 16% (or 8.2%) and the likelihood of soil conservation by 5% (or 2.5%), respectively. Similarly, a hectare increase in farm size decreases the probabilities of choosing livestock, irrigation and changing planting dates by 1%, 3.6% and 6.2%, respectively. Its least effect is on the preference for livestock.

[5] *"Masho" is the "Amharic" name of the crop.*

Table 4: Parameter estimates of the ROL model of climate change adaptation

Explanatory Variables	Livestock		Soil Conservation		Irrigation		Changing Planting Dates	
	Coeff.	**P level**	**Coeff.**	**P level**	**Coeff.**	**P level**	**Coeff.**	**P level**
Gender of HH head	-0.701	0.1740	0.946	0.0353	0.628	0.1719	-0.485	0.2848
Age of HH head	0.023	0.5900	0.089	0.0071	-0.058	0.1063	-0.018	0.5919
Education level	-0.191	0.0002	-0.205	0.0000	-0.215	0.0000	-0.188	0.0000
Farming experience	-0.105	0.0107	-0.105	0.0008	0.041	0.2326	-0.007	0.8374
Household size	0.453	0.0001	-0.104	0.1937	-0.050	0.5659	0.069	0.4424
Farm size	-1.289	0.0044	-0.281	0.4177	-0.839	0.0176	-1.330	0.0003
Farm distance	0.115	0.0200	0.041	0.3054	0.252	0.0000	0.028	0.5027
Average market distance	0.005	0.9453	0.073	0.1672	0.036	0.5243	0.101	0.0841
Farm income	0.069	0.0004	0.032	0.0498	0.024	0.1588	0.013	0.4114
Nonfarm income	-0.064	0.2721	0.116	0.0078	-0.036	0.4464	0.094	0.0280
Experts extension	0.629	0.1566	-0.756	0.0257	0.494	0.1568	-0.481	0.1631
Farmer-farmer extension	-0.752	0.2547	0.729	0.1474	-0.070	0.8953	-0.128	0.8030
Access to credit	-0.037	0.9180	-0.394	0.1625	0.024	0.9346	-0.336	0.2619
Information on climate	0.126	0.7543	-0.749	0.0307	-0.172	0.6209	0.378	0.2886
Perceived temperature	-1.237	0.0009	-1.538	0.0000	-1.739	0.0000	-1.598	0.0000
Perceived rain	0.943	0.2107	0.949	0.0874	2.142	0.0006	1.142	0.0464
Constant	-2.019	0.1435	-1.271	0.2388	-0.685	0.5554	1.803	0.1042
Base category	Multiple cropping							
Number of observations	1125							
Number of groups	225							
LR chi-square, degree of freedom, *p*- value	LR chi2(68) = 604.38 Prob > chi2 = 0.0000							
Log-Likelihood	-773.6117							

In general, an increase in farm size increases the likelihood of adapting to climate change using multiple cropping and soil conservation. This result is expected in the sense that the more households have larger farms, the more they tend to work more intensively on their land instead of going for another alternative to adapt to climate change. They can do this by growing many types and new variety of crops and by applying soil conservation measures. Households with larger farm sizes, therefore, are more probably to diversify their crops especially under dryland conditions and help spread the negative impacts of changes in climatic conditions.

VII. Farm distance from homestead

An increase in farm distance by one kilometer (or by 1 standard deviation, around 3.88 kilometers) that is centered on its mean results in increase in the probabilities of selecting irrigation as the most preferred adaptation strategy by 3.4% (or 13.4%) and livestock by 0.1% (or 0.4%) respectively while, it decreases the probabilities of multiple cropping by 2.3% (or 9%), soil conservation by 0.7% (or 2.8%) and changing planting dates by 0.5% (or 2%), respectively.

Overall, an increase in farm distance increases the likelihood of preferring irrigation highly and secondly, it affects the preference for multiple cropping negatively, while the preference for livestock is the least affected by the change in farm distance. This result suggests that as farm distance from their homes increases, farmers are less likely to go for field operation continuously which could have its own impact on their production and productivity. They, therefore, prefer to rent irrigable lands near to their homes and rear livestock.

VIII. Farm income of households

An increase in farm income of the households increases the likelihood of adapting to climate change using soil conservation, irrigation and livestock. For instance, an increase in farm income by 1 unit (that is birr[6] 1000) centered on the mean increases the probabilities of selecting livestock, soil conservation and irrigation as the most preferred adaptation strategies to climate change by 0.1%, 0.4% and 0.1%, respectively, while the probabilities of multiple cropping and changing planting dates decrease.

It is believed that compared with the other adaptation strategies livestock, irrigation and soil conservation require more financial resources than the others. If farmers have more income, they can afford to produce livestock, develop irrigation and conserve their soil with the latest technologies. This result is reflection of the actual behavior of households; that is, when their income increases, they tend to shift to activities which require more income. This, therefore, supports the argument that subsistence farmers are more likely to vary planting dates and diversify crops as their adaptation options instead of using those expensive methods such as irrigation, livestock and soil conservation.

IX. Nonfarm income of households

Nonfarm income of households is also found to be significant factor that affects their preferences for the adaptation strategies. An increase in nonfarm income enhances the likelihood of adapting to climate change using soil conservation and changing planting dates. Since nonfarm income has highly extreme values in the data, a centered change on the median is found more appropriate than the mean. Therefore, a unit increase in nonfarm income (that is birr 1000) of households centered on the median increases the probabilities of soil conservation and changing planting dates by 2.3% and 0.7%, respectively. On the other hand, it decreases the probabilities of multiple cropping, irrigation and livestock by 1.5%, 1.4% and 0.2%, respectively.

[6] *"Birr" is the Ethiopian currency*

Table 5: Changes in predicted probabilities for a ROL model of climate change adaptation

Explanatory Variables	Multiple cropping	Livestock	Soil conservation	Irrigation	Changing planting dates
Gender of household head	-0.077	-0.030	0.166	0.066	-0.126
Age of household head	-0.005 (-0.050)	0.0002 (0.002)	0.022 (0.227)	-0.013 (-0.135)	0.005 (0.055)
Education level	0.047(0.167)	-0.001(-0.005)	-0.022(-0.078)	-0.016(-0.055)	-0.008(-0.029)
Farming experience	0.010(0.100)	-0.002(-0.019)	0.030(0.252)	0.012(0.130)	0.003(0.029)
Household size	0.007(0.013)	0.011(0.021)	-0.025(-0.048)	-0.006(-0.011)	0.012(0.024)
Farm size	0.160(0.082)	-0.019(-0.010)	0.050(0.025)	-0.069(-0.036)	-0.122(-0.062)
Farm distance	-0.023(-0.090)	0.001(0.004)	-0.007(-0.028)	0.034(0.134)	-0.005(-0.020)
Market distance	-0.015(-0.041)	-0.001(-0.002)	0.009(0.024)	-0.001(-0.003)	0.008(0.022)
Farm income	-0.006(-0.063)	0.001(0.122)	0.004(0.044)	0.001(0.013)	-0.001(-0.006)
Nonfarm income	-0.015(-0.059)	-0.002(-0.009)	0.023(0.092)	-0.014(-0.054)	0.007(0.030)
Expert extension	0.079	0.016	-0.172	0.112	-0.035
Farmer-farmer extension	-0.042	-0.028	0.144	-0.036	-0.037
Access to credit	0.057	0.003	-0.068	0.034	-0.025
Information on climate	0.062	0.007	-0.154	-0.0001	0.084
Perceived temperature	0.325	-0.003	-0.129	-0.123	-0.070
Perceived rain	-0.299	0.006	0.080	0.157	0.056

Note: values given in brackets are for a standard deviation change in the values of continuous variable.

Farmers who have sources of nonfarm income are expected to have nonfarm job which could possibly be a measure they took to climate change. If that is so, it is clear that it will affect negatively the probability of taking some other adaptation measures while it could affect positively the probability of adaptation strategies that can be undertaken in combination with nonfarm jobs, such as varying planting dates. Also, they can exercise soil conservation on their limited land since they have additional non farm income.

X. Extension services from experts

It can be seen from Table 5 that experts' extension services increase the probabilities of using irrigation, multiple cropping and livestock by 11.2%, 7.9% and 1.6%, respectively, to adapt to climate change. However, the probabilities of ranking soil conservation and changing planting dates first are about 17.2% and 3.5% lower for households who received extension services from experts than those who didn't, respectively.

This result implies the importance of increasing institutional support so as to encourage the use of strategies such as irrigation, livestock and multiple cropping to acclimatize to the impacts of climate change. This is because farmers who have better access to extension services have better opportunities to get information on changing climatic conditions and the various farming practices that they can use to adapt to changes in climatic conditions. This is also in line with the result of Nhemachena & Hassan (2007) that access to free extension services significantly increases the probability of taking up adaptation options since extension services provide an important source of information on climate change as well as agricultural production and management practices.

XI. Access to climate forecast information

Access to climate forecast information also increases the likelihoods of preferring multiple cropping as the most preferred strategy by 6.2% and changing planting dates by 8.4%. Similarly, access to this information increases the probability of ranking livestock first by 0.7%, while it decreases that of soil conservation by 15.4% and irrigation by 0.0001%, almost negligible effect on irrigation.

Generally, the likelihood of adapting to climate change using multiple cropping, changing planting dates and livestock is higher for those households who received climate forecast information than those who did not. This result is, therefore, an indication of the importance of information on climate forecast to enhance climate change adaptation. Farmers who received climate forecast information are more likely to grow different crop varieties and vary their planting dates to suit the prevailing and forecasted climate conditions.

XII. Long-term temperature perception

Farmers were also requested to indicate whether they perceived changes in the *long-term average* temperature and rainfall. It is found that most of the farmers have perceived changes in the long-term average temperature and rainfall, though there are some farmers who perceived only recent period variations.

Perceiving the change in long-term average temperature increases the probability of preferring multiple cropping to adapt to climate change by 32.5%; whereas, the probabilities of selecting soil conservation, irrigation and changing planting dates are around 12.9%, 12.3% and 7% lower for those farmers who perceived the change in the long-term average temperature than those who did not perceive it, respectively. The farmers know that increasing temperature is damaging to their production and need to respond to this through the use of different adaptation methods. However, perceiving the change in long-term average temperature enhances adaptation using only multiple cropping, but of course with the largest change in the probability. This possibility is due to the fact that farmers who perceive the warmer change in the long-term temperature are likely to grow different heat-tolerant crop varieties, the most affordable practice next to changing planting dates by subsistence smallholder farmers. Since the farmers are located in the same agroecological zone and the area is already hotter, a warmer change in the temperature would not highly affect their farming practices except the usually practiced systems of multiple cropping. This is in line with the result of Kurukulasuriya & Mendelsohn (2007) where crop choice is very climate sensitive and as temperatures warm, farmers will shift towards more heat tolerant crops.

XIII. Long-term rainfall perception

The effect of perceiving the change in the long-term average rainfall is also presented in the last row of **Table 5**. As the result indicates, perceiving change in the average rainfall has a positive effect on the likelihood of adaptation to climate change using all the strategies except multiple cropping. That is, it increases the probability of preferring irrigation by 15.7%, soil conservation by 8%, changing planting dates by 5.6% and livestock by 0.6%. In contrast to this, perceiving the change in long-term average rainfall decreases the probability of selecting multiple cropping to adapt to climate change by around 29.9%.

More clearly, the likelihoods of preferring soil conservation, irrigation and changing planting dates to adapt to climate are higher for those who noticed the long-term change in the rainfall pattern than those who did not. This is expected result because farmers who perceive shortage or decrease in the rainfall are more likely to take adaptation measures to acclimatize to it. For example, during rainfall shortage, using irrigation is very convincing. The same is to soil conservation measures to maintain or keep moisture of their soil. Changing the planting dates according to their perception on the pattern of the rainfall is also important and expected measure.

Generally, noticing the change in the long-term average climatic conditions has its own significant influence on the farmers' decisions about the choice of adaptation strategies to climate change. Farmers who are aware of changes in climatic conditions have higher chances of taking adaptive measures in response to the observed changes.

6. Conclusions and Policy Implications

This study analyzed the determinants of farmers' preference for climate change adaptation strategies and also identified barriers to climate change adaptation using a cross-sectional data collected from 225 households. The study reveals that lack of information/knowledge and shortage of money are the main constraints to adaptation followed by shortage of land, and unsuitability of their land and poor potential for irrigation. Rank-Ordered Logit (ROL) Model is applied to examine the factors that derive households' observed preference for climate change adaptation strategies. The model's dependent variable is the rank assigned by each household for each adaptation strategy, while the explanatory variables include household and farm characteristics, institutional factors, and long-term climate change perceptions of the farmers. Estimation is done by using multiple cropping as a base category. The result indicates that multiple cropping is the most preferred and frequently applied adaptation strategy to climate change. The next most preferred adaptation strategy is soil conservation followed by irrigation and changing planting dates, consecutively, while livestock is the least preferred and used adaptation strategy of farmers in the study area. It also shows that all variables included in the model, except market distance, farmer-to-farmer extension and credit access, are significant determinants of farmers' preference for the climate change adaptation strategies. Then, changes in predicted probabilities of preferring each adaptation strategy for discrete changes in the independent variables are estimated.

All variables representing the households' characteristics (gender, age, farming experience and education level of the household head, household size, and farm and nonfarm income) are found to be significant factors that affect adaptation strategy preference of farmers. Among these variables education level, farm and nonfarm income can be influenced by policy and program interventions to enhance the farmers' adaptation to climate change. Moreover, the result showed that farmers' preference for climate change adaptation strategies is sensitive to farm characteristics such as farm size and farm distance to homestead. These issues could be addressed in combination with efforts to raise income of the households. Experts' extension services on crop and livestock production and climate forecast information are also significant institutional factors influencing households' preference for the adaptation strategies.

Moreover, long-term climate change perception of the farmers' (perception on long-term average temperature and rainfall) are found to be significant factors affecting their decision regarding the choice of climate change adaptation strategies. Noticing the changes in the long-term temperature and rainfall enhances the probability of taking various adaptation measures. Specifically, perceiving the change in the average temperature increases the likelihood of using multiple cropping to adapt to climate change, and noticing the change in the average rainfall, on the other hand, enhances the chances of adapting to climate change using irrigation, soil conservation, changing planting dates and livestock.

Based on the findings, the researcher has arrived at the following policy implications. Strengthening efforts on enhancing the farmers' adaptive capacity to climate change is an important policy measure that should be considered. Encouraging investment at local level on the barriers to adaptation is a good policy option. For instance, developing good information system among farmers, expanding credit facilities *suitable* to farmers, fostering research and development on agriculture specific to the area, and promoting water conservation and irrigation schemes in the area among farmers are suggested intervention measures. The finding confirms the important roles of research and developments in changing crop varieties suitable to the area and the changing climatic conditions rather than sticking on common crops that frequently fail to meet the farmers' needs. For instance, the recently introduced new crop, *Masho*, to the area is highly preferred and applied by the local farmers. Therefore, policies or programs aimed to reduce climate change impacts need to encourage investments on soil conservation, irrigation development, and researches on livestock and crop varieties. Supporting and training farmers on soil conservation measures, irrigation development and changing planting dates can improve adaptation practices to climate change.

On the other hand, designing programs to increase the farmers' education level is an important policy measure in enhancing adaptation to climate change and thus reduce its impact on the farmers. In addition to its role of delivering knowledge, education can create opportunities for the households to gather information on new technologies or methods of production, better information on climate change and farming practices that suit to it. Furthermore, programs that can increase farm income of households such as better supply of inputs at fair price, and creating better access to markets and transportation facilities are suggested as policy measures to help farmers adapt to climate change. Promoting investments to create job opportunities to raise farmers' nonfarm income is also suggested to enhance farmers' capacity.

It also believed that better access to agricultural extension services for farmers has the potential to increase farmers' awareness of changing climatic conditions and suitable adaptation responses to it. Therefore, a policy with the objective of enhancing farmers' adaptation to climate change should take in to account the significant roles of agricultural extension services and climate forecast information on the farmers' practices of climate change adaptation.

The researcher, therefore, argue that information on the prevailing and forecasted climate is very helpful especially for subsistence farmers who focus on growing crops and can not afford to exercise irrigation or soil conservation, because subsistence farmers are more likely to vary planting dates and diversify crops than changing to different crops or using expensive adaptation technologies such as irrigation and soil conservation. Hence, promoting less-costly adaptation options (such as multiple cropping, changing crop variety, changing planting dates etc) among smallholder farmers could have the potential to positively enhance adaptation to climate change by subsistence farmers.

Generally, it is suggested that government bodies at different level, meteorological departments, and agricultural offices should play important role in raising farmers' awareness of the prevailing and expected changes in the climate through proper mechanisms that are easily accessible to the farmers such as extension services, local medias, social groups such as edir, farmers gatherings, and input and output traders. This awareness creation effort should be combined with the different types of crop and livestock production and management practices that farmers could take up as adaptation measures to the change in the climate. Finally, the researcher suggests further research and developments specific to agroecologies, and they need to move towards making farmers more resilient to damaging changes in climate.

***Acknowledgement**: The author would like to thank Dr Assefa Admassie[7] for his helpful suggestions and comments as well as the Addis Ababa University, the African Economic Research Consortium (AERC) and Ethiopian Development Research Institute (EDRI) for their financial support. Last but not least, my gratitude goes to my brothers, mother and friends to their important contributions.*

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