Journal of Economics and Sustainable Development www.iiste.org
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.3, No.14, 2012

Climate Change Adaptation Strategies of Smallholder Farmers: The Case of Babilie District, East Harerghe Zone of Oromia Regional State of Ethiopia

Aemro Tazeze.[1] Jemma Haji[2] (Associate Professor) and Mengistu Ketema[2] (Assistance Professor)

1. School of Agricultural Economics and Agribusiness, P.O box 95, Haramaya University, Ethiopia
2. School of Agricultural Economics and Agribusiness, P.O box 138, Haramaya University, Ethiopia

E-mail of the Corresponding author: aemrot@gmail.com

ABSTRACT

Climate change is a global phenomenon. Its impact on agricultural activities in the developing countries has been increasing. Higher temperature and decreasing precipitation levels caused by climate change depresses crop yields. This is particularly true in low-income countries where adaptive capacities are perceived to be low. The vulnerability of poor countries could be due to weak institutional capacity, limited engagement in environmental and adaptation issues, and lack of validation of local knowledge. A better understanding of the local dimensions of vulnerability is therefore essential to develop appropriate adaptation measures that can mitigate these adverse consequences. The main aim of this study was to identify the determinants of farmer's choice of adaptation strategies to climate change in the Babilie district of Eastern Ethiopia. Both primary and secondary data sources were used for this study. Primary data were collected from a randomly selected 160 sample households interviewed through a semi-structured questionnaire, key informants interview and focus group discussion. Multinomial logistic regression analysis was estimated to analyze the factors influencing households' choice of adaptation strategies to climate change. The result from the multinomial logit analysis showed that sex of the household head, age of the household head and education of the household head, family size, livestock ownership, household farm income, non/off farm income, access to credit, distance to the market center, access to farmer-to-farmer extension, agro ecological zones, access to climate information, and extension contact have a significant impact on climate change adaptation strategies. Therefore, future policy should focus on awareness creation on climate change through different sources such as mass media and extension, encouraging informal social net-works, facilitating the availability of credit, enhancing research on use of new crop varieties that are more suited to drier conditions and different agro ecological zones.

Key words: Climate change, Babilie district of Eastern Ethiopia, Adaptation to climate change, Multinomial logit

1. INTRODUCTION

Climate change affects agriculture and agriculture also affects climate change. Agriculture affects climate change through the emission of greenhouse gases (GHG) from different farming practices (Maraseni *et al.*, 2009; Edwards-Jones *et al*., 2009). Adverse climate change impacts are considered to be particularly strong in countries located in tropical Africa that depend on agriculture as their main source of livelihood (IACR, 2004; Dixon *et al*., 2001; IPCC, 2001a).

Agriculture is the main stay of the Ethiopian economy. It comprises about 43 % of GDP, generates 90% of foreign exchange earnings and employs more than 80% of the population (MoA, 2010). The sector is dominated by small-scale mixed crop livestock production with very low productivity. The major factors responsible for low productivity include reliance on traditional farming techniques, soil degradation caused by overgrazing and deforestation, poor complementary services such as extension, credit, marketing, infrastructure and climatic factors such as drought and flood (Chilot, 2007; Belay, 2003; Arega, 2003; Devereux, 2000). These factors reduce the adaptive capacity and increase the vulnerability of farmers to future shocks, such as climate change, which negatively affect the performance of the already weak agriculture.

The fact that climate has been changing in the past and continues to change in the future implies the need to understand how farmers perceive climate change and adapt in order to guide strategies for adaptation in the future. Studies indicate that farmers' adapt to reduce the negative impacts of climate change (Mertz *et al*., 2009; Ishaya and Abaje, 2008; David *et al*., 2007).

Droughts in Ethiopia can shrink household farm production by up to 90% of a normal years output (World Bank,

2003) and could lead to the death of livestock and human beings. Studies show that the frequency of drought has increased over the past few decades, especially in the lowlands (NMSA, 2007; Lautze *et al*., 2003). Ethiopia experienced drought early in 2006, but it also suffered severe floods in early August that year that killed more than 200 people in the eastern part of the country. In response to the recurrent droughts and related environmental calamities, farmers in Ethiopia have developed different coping strategies (Devereux and Guenther, 2007; MoFED, 2007; Belay *et al*., 2005).

Adaptation can be viewed as reducing the severity of many impacts when adverse conditions prevail. That is, adaptation reduces the level of damages that might have otherwise occurred. The success of adaptation depends critically on the availability of necessary resources, not only financial and natural resources, but also knowledge, technical capability, and institutional resources (PCGCC, 2004). In addition, many social, economic, technological and environmental trends also critically shape the ability of farmers to perceive and adapt to climate change. Knowledge of the adaptation methods and factors affecting farmers' choices enhances efforts directed towards tackling the challenges that climate change is imposing on farmers (Deressa *et al*., 2009).

Thus, for many poor countries that are highly vulnerable, understanding farmers' response to climate change is crucial in designing appropriate adaptation strategies (Mohmud *et al*., 2008). The vulnerability of poor countries is due to weak institutional capacity, limited engagement in environmental and adaptation issues, and a lack of validation of local knowledge (Adams *et al*., 1998).

Experience has shown that identified adaptation measures do not necessarily translate into changes, because adaptation strategies to climate change and physiological barriers to adaptation are local specific (IPCC, 2007). A better understanding of the local dimensions of climate change is essential to develop appropriate adaptation measures that will mitigate adverse consequences of climatic change impact. The knowledge of the adaptation choices and factors affecting the adaptation methods to climate change enhance policy towards tackling the challenge that climate change is imposing on farm households having little adaptation capacities.

Babilie is one of the districts in eastern *Harerghe* which is affected by climate change like recurrent drought and erratic nature of rainfall. Furthermore, there is no earlier study about climate change adaptation strategies of smallholder farmer's in the study area, using household-specific survey data. Hence, this study investigates key factors that govern farmers' choice of adaptations towards climate change.

2. EMPIRICAL STUDIES ON ADAPTATION TO CLIMATE CHANGE

Different studies regarding farmers' choices of adaptation options and their determinants were carried out in different countries including Ethiopia. However, most of the studies were undertaken at a macro level, which might make the results vague to generalize about specific households. Adaptation to climate change is an essential strategy for reducing the severity and cost of climate change impacts. Adaptation measures help farmers guard against losses due to increasing temperatures and decreasing precipitation (IPCC, 2007).

The influence of age of household on adaptation has been mixed in the literature. For example Wegayehu and Drake (2003) in their study of Eastern highlands of Ethiopia found that age had no influence on farmer's decision to participate in soil and water conservation activities. Others such as Nyangena (2007) and Dolisca *et al*. (2006) however, found that age is significantly and negatively related to farmer's decisions to adopt in soil and water conservation and forestry management programs respectively. Age of the household head, which represents experience, affected adaptation to climate change positively. Experience in farming increases the probability of uptake of adaptation measures to climate change (Maddison, 2006; Nhemachena and Hassan, 2008; Aymone, 2009; Deressa *et al*., 2009).

The empirical adaptation literature shows that larger family size had enable farmers to take up labor intensive adaptation measures (Nhemachena and Hassan, 2008; Aymone, 2009). Aymone (2009) found that a large household are more willing to choose the adaptations options such as soil conservation techniques, chemical treatments that are labor intensive. For most of the adaptation methods, however, Deressa *et al*. (2009) found that increasing household size did not significantly increase the probability of adaptation, though the coefficient on the adaptation options has a positive sign.

Educated and experienced farmers are expected to have more knowledge and information about climate change and agronomic practices that they can use in response. Maddison (2006), found that farmers' awareness of changes in climate attributes (temperature and precipitation) is important for adaptation decision making. Deressa *et al*. (2009) also found that education was significantly increases soil conservation and changing planting dates as an adaptation method. Moreover, almost all of the marginal values of education are positive across all adaptation options. Similarly, various studies have shown that sex is an important variable affecting adaptation decision at the farm level. For example, Deressa *et al*. (2009) and Nhemachena and Hassan (2008) found that, male-headed households adapt more readily to climate change. However, Aymone (2009) found that education level and gender did not have a significant impact on the probability of choosing any adaptation techniques.

Large-scale farmers are more likely to adapt because they have more capital and resources (Aymone, 2009). Nhemachena and Hassan (2008) suggest that capital, land and labor are important factors for coping with and adapting to climate change. The choice of the suitable adaptation measure depends on factor endowments (i.e. family size, land area and capital resources) at the disposal of farming households.

The farm income of the households has a positive and significant impact on conserving soil, using different crop varieties, and changing planting dates. In addition to farm income, nonfarm income also significantly increases the likelihood of planting trees, changing planting dates, and using irrigation as adaptation options. Deressa *et al*. (2009) found that nonfarm income has a negative relationship with the adaptation of soil conservation practices and the use of different crop varieties, although these results are not statistically significant.

The empirical results suggest that expanding smallholder farmers' access to off-farm sources of income increases the probability that they will invest in farming activities (Aymone, 2009). The ownership of livestock is positively related to most of the adaptation options, even though the marginal impacts are not significant. Deressa *et al*. (2009) found that ownership of livestock is positively related to the use of adaptation methods such as conserving soil, planting trees, and changing planting dates. However, it is negatively related to the use of different crop varieties and irrigation, although it was not statistically significantly.

Different studies have shown that access to credit increases the likelihood of adaptation (O'Brien *et al*., 2000; Aymone, 2009; Deressa *et al*., 2009). A study in Tanzania, O'Brien *et al*. (2000) reports that despite numerous adaptation options that farmers are aware of and willing to apply, the lack of income to purchase the necessary inputs and other associated equipment (e.g., purchasing seeds, acquiring transportation, hiring temporary workers) is one of the significant constraints to adaptation..

Better access to extension services seems to have a strong positive influence on the probability of choosing in adaptation measures (Aymone, 2009; Deressa *et al*., 2009). Aymone (2009) argue that farmers who have access to extension services are more likely to be aware of changing climatic conditions and to have knowledge of the various management practices that they can use to adapt to changes in climatic conditions. Information on temperature and rainfall also has a significant and positive impact on the likelihood of using different crop varieties. Having access to farmer-to-farmer extension increases the likelihood of using different crop varieties and planting trees (Deressa *et al*., 2009).

3. METHODOLOGY

3.1. Sampling Techniques and Sample Size

The study area, Babilie District of the Eastern Harerghe zone of Oromia regional state of Ethiopia was selected for this study because; it is affected by climate change like recurrent drought and erratic nature of rainfall. A two stage sampling technique was applied to select sample households. In the first stage, five peasant associations were randomly selected out of the total 21 peasant associations in the district. In the second stage, a total of 160 households were selected randomly using probability proportional to size sampling technique.

Both primary and secondary data sources were used to collect qualitative and quantitative data for this study. Primary data were collected from sample households and focus group discussions in the district by preparing and distributing semi-structured questionnaire through interviewing method. Secondary data sources have been important source of information for this study. Time series rainfall and temperature data were collected from the National Meteorological Agency (NMA) branch office.

3.2.Estimation of Factors Affecting Choice of Climate Change Adaptation Strategies

The analytical approaches that are commonly used in adoption studies involving multiple choices are the multinomial logit (MNL) and multinomial probit (MNP) models. Both the MNL and MNP are important for analyzing farmers' adaptation decisions as these are usually made interchangeable. These approaches are also appropriate for evaluating alternative combinations of adaptation strategies, including individual strategies (Wu and Babcock, 1998; Hausman and Wise, 1978). This study utilizes a MNL model to analyze the determinants of farmer's decisions because it is widely used in adoption decision studies involving multiple choices and is easier to compute than its alternative, the MNP.

The advantage of using a MNL model is its computational simplicity in calculating the choice probabilities that are expressible in analytical form (Tse, 1987). This model provides a convenient closed form for underlying choice probabilities, with no need of multivariate integration, making it simple to compute choice situations characterized by many alternatives. In addition, the computational burden of the MNL specification is made easier by its likelihood function, which is globally concave (Hausman and McFadden, 1984). The main limitation of the model is the IIA property, which states that the ratio of the probabilities of choosing any two alternatives is independent of the attributes of any other alternative in the choice set (Tse, 1987; Hausman and McFadden, 1984).

Alternatively, the multinomial probit model (MNP) specification for discrete choice models does not require the assumption of the IIA (Hausman and Wise, 1978), and a test for this assumption can be provided by a test of the 'covariance' probit specification versus the 'independent' probit specification, which is very similar to the logit specification. The main drawback of using the MNP is the requirement that multivariate normal integrals must be evaluated to estimate the unknown parameters. This complexity makes the MNP model an inconvenient specification test as compared to the MNL model (Hausman and McFadden, 1984).

The household decision of whether or not to undertake adaptation strategies for climate change was considered under the general framework of utility or profit maximization (Deressa *et al*., 2008; Norris and Batie, 1987). It was assumed that economic agents such as households used adaptation options only when the perceived utility or net benefit from using a particular option was significantly greater than in the base category. In this context, the utility of the economic agents is not observable, but the actions of the economic agents could be observed through the choices they made. Supposing that U_j and U_k represent households utility for two choices, β_j and β_k respectively, the linear random utility model could then be specified as follows:

$$U_j = \beta_j' X_i + \varepsilon_j \ and \ U_k = \beta_k' X_i + \varepsilon_k \tag{1}$$

where U_j and U_k are perceived utilities of adaptation options *j* and *k*, respectively, X_i is the vector of explanatory variables which influences the perceived desirability of each option; *j* and k are the parameters to be estimated, and ε_j and ε_k are error terms assumed to be independently and identically distributed (Greene, 2003). For climate change adaptation options, if a household decides to use option *j,* then it follows that the perceived utility or benefit from option *j* is greater than the utility from other options (say, *k*) depicted as:

$$U_{ij}(\beta_j' X_i + \varepsilon_j) > U_{ik}(\beta_k' X_i + \varepsilon_k), j \neq k \tag{2}$$

Based on the above relationship, we could define the probability that a household will use option *j* from among a set of climate change adaptation options as follows:

$$P(A_i = 1/X) = (U_{ij} > U_{ik}) \tag{3}$$

Equation (3) can be expressed and simplified in the following manner:

$$P(\beta_j' X_i + \varepsilon_j - \beta_k' X_i - \varepsilon_k) > 0/X \tag{4}$$

$$P(\beta_j' X_i - \beta_k' X_i + \varepsilon_j - \varepsilon_k) > 0/X \tag{5}$$

$$P(\beta_j^* X_i + \varepsilon^*) > 0/X = F(\beta_k^* X_i) \tag{6}$$

Where

P is a probability function;

U_{ij}, U_{ik}, and X_i are as defined above;

$\varepsilon^* = \varepsilon_j - \varepsilon_k$ is a random disturbance term;

$\beta^* = \beta_j' - \beta_k'$ is a vector of unknown parameters that can be interpreted as a net influence of the vector of independent variables influencing adaptation; and $F(\beta_k^* X_i)$ is a cumulative distribution function of ε^* evaluated at $\beta^* X_i$. The exact distribution of F depends on the distribution of the random disturbance term, ε^*. According to Greene (2003), several qualitative choice models can be estimated for the above function depending on the assumed distribution of the random disturbance term.

To describe the MNL model, let A_i be a random variable representing the adaptation measure chosen by any farm household. We assume that each farmer faces a set of alternatives, mutually exclusive choices of adaptation measures. These measures are assumed to depend on a number of climate attributes, socio economic characteristics and other factors, X. The MNL model for adaptation choice specifies the following relationship between the probability of choosing option A_i and the set of explanatory variables X as follows (Greene, 2003):

$$Pro(A_i = j) = \frac{e^{\beta'_j x_i}}{1 + \sum_{k=0}^{j} e^{\beta'_j x_i}} \; j = 0, 1 \ldots J, \quad (7)$$

Where β_j is a vector of coefficients on each of the independent variables X. Equation (7) can be normalized to remove indeterminacy in the model by assuming that $\beta_0 = 0$ and the probabilities can be estimated as:

$$Pro(A_i = j) = \frac{e^{\beta'_j x_i}}{1 + \sum_{k=0}^{j} e^{\beta'_j x_i}} \; j = 0, 1 \ldots J, \beta_0 = 0 \quad (8)$$

Estimating equation (16) yields the J log-odds ratios

$$\ln\left(\frac{P_{ij}}{P_{ik}}\right) = X'_i(\beta_j - \beta_k) = X'_i \beta_j, if, k = 0 \quad (9)$$

The dependent variable is therefore the log of one alternative relative to the base alternative. The MNL coefficients are difficult to interpret, and associating with β_j the outcome is tempting and misleading. To interpret the effects of explanatory variables on the probabilities, marginal effects are usually derived as (Greene, 2003):

$$\frac{\partial p_j}{\partial x_i} = P_j\left(\beta_j - \sum_{k=0}^{j} P_k \, \beta_k\right) = P_j(\beta_j - \bar{\beta}) \quad (10)$$

The marginal effects measure the expected change in probability of a particular choice being made with respect to a unit change in an explanatory variable (Greene, 2003; Long, 1997). The signs of the marginal effects and respective coefficients may be different, as the former depend on the sign and magnitude of all other coefficients.

4. *RESULTS AND DISCUSSION*

4.1. **Determinants of Farmers' Choice of Adaptation Strategies to Climate Change**

Multinomial logistic regression analysis was estimated to determine the factors influencing a households' choice of adaptation strategies to reduce adverse effect of climate change. The estimation of the MNL model was made by normalizing one category, which is normally referred to as the "base category." In this analysis, "no adaptation" option was used as the base category. The likelihood ratio statistics as indicated by the chi-square statistics was found to be highly significant (Table 1).

Finally, the model was tested for the validity of the Independence of Irrelevant Alternatives (IIA) assumptions by using Hausman's test. This test failed to reject the null hypothesis of independence of the climate change adaptation options, suggesting that the multinomial logit (MNL) specification is appropriate to model climate change adaptation practices of smallholder farmers in the study area. MNL model specification was used by several researchers to model climate change adaptation practices of smallholder farmers in Africa (Deressa *et al*. 2009; Nhemachena and Hassan, 2008).

The parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent variable; they do not represent the actual magnitude of change of probability. Thus, the marginal effects of the MNL, which measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable, were calculated. In all cases, the estimated coefficients were compared with the base category of no adaptation. Table 1 presents the marginal effects along with the levels of statistical significance.

Before running the model, it is useful to look into account the problem of multicollinearity among the independent variables. To this effect, all the fourteen explanatory variables were checked for multicollinearity using Variance Inflation Factor (VIF). VIF for all variables were less than 10 (1.1–2.13). Which indicate that multicollineraity is not a serious problem in model estimation. Therefore, all the hypothesized explanatory variables were included in the model. The estimated coefficients of the MNL model and their levels of significance are presented in Table 1. Therefore, in this study, only those variables, whose coefficients were statistically significant at less than or equal to 10% probability levels were discussed.

Sex of household head: The result indicates that being male as a household head increases adaptation to climate change. Being male-headed households were more likely to adopt improved crop variety and crop diversification at 5% and 1% significant level, respectively. Male households are better in adapting some measures to climate change also agrees with the fact that male-headed households often have a higher probability of adopting agricultural technologies, at least in some parts of Africa (Buyinza and Wambede, 2008). This is so because, male-headed households are relatively flexible in search of improved crop varieties and in a better position to pull their labor force in order to adapt improved crop varieties and crop diversification. The other possible reason for this is that much of the farming activities are done by male while female are more involved in the processing, this gives male headed households an edge in terms of farming experience and information on various adaptation strategies and what is needed to be done in response to the climatic instability.

Age of household head: Age of household head, which represents experience, affected adaptation to climate change positively and significantly. Because as the age of the household head increases, the person is expected to acquire more experience in weather forecasting and that helps increase in likelihood of practicing different adaptation strategies to climate change.

Education of the household head: It had a positive and strong relationship with the dependent variable showing that education increases the probability of adapting to climate change. This could possibly, literate farmers who are more likely to respond to climate change by making best adaptation option based on his preference and influences individual decision making as it tends to reduce farmers' risk aversion, this finding is in line with the investigation of Temesgen (2010).

Family size: Family size of the households has negatively and significant impact on the probability of adaptation options to climate change. A one unit increase in family size would result in a decrease in the probability of using improved crop variety about 5 percent. This could be because households with large families may be forced to divert part of the labor force to off-farm activities in an attempt to earn income in order to ease the consumption pressure imposed by a large family rather than adopting improved crop variety

Livestock ownership: The ownership of livestock of the households has positive and significant impact on the probability of using improved crop variety and soil and water conservation techniques as adaptation strategies. A unit increase in the tropical livestock unit would result in increase in the probabilities of using improved crop variety and soil and water conservation techniques by 0.4% and 2.9% at 5% significant level, respectively. Because the livestock plays a very important role by serving as a source of income in order to purchase improved crop variety and by providing traction (especially oxen) and manure required for soil fertility maintenance.

Farm income: The farm income of the households surveyed has a positive and significant impact on improved crop varieties, soil and water conservation techniques, and crop diversification. When the main source of income in farming would increase, farmers tend to invest on productivity smoothing options such as improved seed varieties, soil and water conservation and crop diversification options.

Off/non farm income: Off/non farm income is also positively related to improved crop variety, soil and water conservation techniques, adjusting planting date and crop diversification at 1% level. Non/off farm income increases the likelihood of improved crop variety, adjusting planting date and crop diversification. But off/non farm income decreases the probability of adoption of soil and water conservation techniques. This indicates that when farmers have options for non/off farm incomes, they can afford the cost by using less of agronomic practices such as soil and water conservation techniques.

Access to credit: Access to credit has a positive and significant impact on likelihood of using adjusting planting date and combination of improved crop variety and crop diversification. Access to affordable credit increases financial resources of farmers and their ability to meet transaction costs associated with various adaptation options they might want to take (Nhemachena and Hassan, 2008). This result implies the important role of increased institutional support in promoting the use of adaptation options to reduce the negative impact of climate change.

Extension contact: It has positive and significant impact on improved crop variety and soil and water conservation techniques at 5% significant level, where as extension contact has negative and significant effect on crop diversification at 1% significant level. Having access to extension contact increases the probability of using improved crop variety and soil and water conservation techniques by 0.05% and 0.2% respectively. Extension contact was found to be an important factor motivating increased intensity of use of specific soil and water conservation practices (Tizale, 2007), where as extension contact reduces the likelihood of using crop diversification, because extension agent might influence decision of farmers to use other type of adaptation option to cope up with adverse impacts of climate change.

Farmer to farmer extension: Access to farmer to farmer extension has a positive and significant impact on the likelihood of using a combination of crop diversification and improved crop varieties by 0.09%. Because, farmer to farmer extension and social network are increase awareness and use of climate change adaptation options.

Agro-ecological features: Farmers living in different agro ecological zones make use of different adaptation methods. Due to that farmers living in arid areas are more likely to adjust planting date. Therefore, farming in the arid area significantly increases the probability of adjusting planting date by 5.8%, where as farming in the semi arid area increases the likelihood a using combination of improved crop variety and crop diversification by 3.54%, at 10% significant level.

Access on climate information: Even though service on climate information delivery is not formal, access to information from different sources has significant impact on the adaptation combination of improved crop variety and crop diversification. Indeed, it is an important precondition for farmers to take up adaptation measures (Madison 2006). Getting information about seasonal forecasts and climate change increase the probability of using a combination of improved crop variety and crop diversification by 2.7 % at 10% significant level. Because the availability of better climate and information helps farmers make comparative decisions among alternative adaptation practices and hence choose the ones that enable them to cope better with changes in climate (Baethgen *et al*., 2003; Jones, 2003).

Distance from the market center: Distance from the market center is also negatively related to water and soil conservation adaptation option. Proximity to market is an important determinant of adaptation, presumably because the market serves as a means of exchanging information with other farmers (Maddison, 2006). Hence being more far market center decreases the probability of using soil and water conservation by 15.89% at 5% significant level. Because better access to markets enables farmers to buy new soil and water conservation technologies and other important inputs they may need if they are to change their practices to cope with predicted changes in future climate, so that needs for improving household farmers' relatively poor access to markets.

4. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary and Conclusions

Identify factors influencing farm-level adaptation can facilitate the formation of policies and investment strategies that help moderate potential adverse consequences of long-term climate change. Because smallholder farmers tend to have a low capacity to adapt to changes in climatic conditions, policies that help these farmers adapt to global warming and associated climatic extremes are particularly important. A better understanding of the local dimensions of vulnerability is therefore essential to develop appropriate adaptation measures that will mitigate these adverse consequences. The knowledge of the adaptation methods to climate change enhance policy towards tackling the challenge that climate change is imposing on Ethiopian farmers. In relation to this, the study attempted to identify factors affecting the choice of climate change adaptation strategies on smallholder farmers at Babilie district, East Harareghe zone of Oromia regional state of Ethiopia.

Mutually exclusive adaptation strategies used by farmers in the study area include; changing/adjusting planting date, use soil and water conservation techniques, use of improved crop varieties (like short duration varieties and drought resistance varieties), crop diversification (mixed cropping, intercropping and dividing farm lands in to varying crops), and combination of improved crop varieties and crop diversification.

Multinomial logistic regression analysis was employed to determine the factors influencing a household's choice of adaptation strategies related to climate change. The result from the multinomial logit analysis shows that sex, age and education of the household head, family size, livestock ownership, farm income, off/non farm income, access to credit, distance to the market center, farmer-to-farmer extension, agro ecological setting, access to climate information, and extension contact have a significant impact on choice of climate change adaptation method.

5.2. Recommendations

Based on the evidences obtained from this finding due to low adaptive capacity of climate change, there is a need for urgent action aimed at addressing the causes of climate change adaptation strategies in this study. These include the following:

- Social and physical infrastructure should be improved and institutions dealing with climate related issues including the meteorology agency be strengthened to increase adaptive capacity.
- In terms of policy implications it appears that improving education would do most to hasten adaptation and increase households' decision making regarding the key adaptation techniques.

- Policies aimed at 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 adapt to climate change.
- Combining access to extension, farmer-to-farmer extension and credit ensures that farmers have the information for decision making. Therefore, Policy interventions which encourage formal and informal social networks can promote group discussions, training and better information flows that help to enhance adaptation to climate change.
- Better access to markets reduces transport and other market related transaction costs and enhances the uptake of farm-level adaptation measures..Hence it is necessary to improve farmers' relatively poor access to markets.
- 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.
- Moreover, farmers living at different agro ecological settings used different adaptation methods. Thus, future policy has to aim at providing adaptation technologies through agro ecology based research. Information on appropriate adaptive measures should be made available to the entire community. As part of this effort, communication between policymakers, nongovernmental organizations, research institution, Universities, and the media, among other actors, should be strengthened in order to ensure accurate information is available and widely disseminated.

ACKNOWLEDGMENTS

The author is grateful for the financial support from Haramaya University and DAAD in country Scholarship. In addition to that the author would like to thank Gebrelibanos Gebremedhin for reviewing this report and giving constructive comments.

REFERENCES

Adams, R.M., Hurd, B.H., Lenhart, S. and N., Leary, 1998. Effects of global change on agriculture: an interpretative review. *Climate Research,* 11: 19-30.

Arega Demelash, 2003. Improved production technology and efficiency of small holder farmers in Ethiopia: Extended Parametric and non-parametric approaches to production efficiency analysis. PhD Thesis. Department of agricultural economics, Extension and rural development. University of Pretoria, South Africa.

Aymone, G. G., 2009. Understanding farmers' perceptions and adaptation to climate change and variability: The case of the Limpopo basin, South Africa. IFPRI Discussion paper 00849, International Food Policy Research Institute: Washington DC.

Baethgen, WE, Meinke, H and A., Gimene, 2003. Adaptation of agricultural production systems to climate variability and climate change: Lessons learned and proposed research approach. Insights and Tools for Adaptation: Learning from Climate Variability, 18–20 November, 2003, Washington, DC.

Belay Kassa, 2003. Agricultural extension in Ethiopia: the case of participatory demonstration and training extension system. *Journal of Social Development in Africa,* 18(1):50-83.

Belay Kassa, Fekadu Beyene and Manig, W., 2005. Coping with drought among pastoral and agro-pastoral communities in eastern Ethiopia. *Journal of Rural Development,* 28: 185-210.

Buyinza M. and Wambede, N., 2008. Extension of agroforestry technology adoption: Mixed intercropping of crotalaria (*Crotaloria grahamiana*) and maize (*Zea mays L.*) in *Kabale* district, Uganda. *Environmental Research Journal,* 2 (3): 131-137.

Chilot Yirga, 2007. The dynamics of soil degradation and incentives for optimal management in central highlands of Ethiopia. PhD Thesis. Department of agricultural economics, extension and rural development. University of Pretoria, South Africa.

David, S., Thomas G., Twyman C., Osbahr H., and B., Hewitson, 2007. Adaptation to climate change and variability: farmer responses to intra-seasonal precipitation trends in South Africa. *Climatic Change*, 83: 301-322.

Deressa Temesgen, R. M. Hassan, Tekie Alemu, Mahmud Yesuf and C. Ringler, 2008. Analyzing the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile Basin of Ethiopia. IFPRI Discussion Paper, September, 2008.

Deressa Temesgen, R.M., Hassan, C., Ringler, Tekie Alemu and Mahmud Yesuf, 2009. Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global Environmental Change,* 19: 248-255.

Devereux, S., 2000. Food security in Ethiopia: A discussion paper for DFID. Institute for Development Studies, Sussex.

Devereux, S., and B., Guenther, 2007. Social protection and agriculture in Ethiopia. Country case study paper prepared for a review commissioned by the FAO on 'Social Protection and Support to Small Farmer Development'.

Dixon, J., Gulliver, A. and Gibbon, D., 2001. Farming systems and poverty: Improving farmers' livelihoods in a changing world. FAO (Food and Agriculture Organization), Rome, and World Bank, Washington, DC.

Dolisca, F, Carter, R.D., McDaniel, J.M,. Shannon, D.A., and Jolly, C.M., 2006. Factors

influencing farmers' participation in forestry management programs: A case study from

Haiti. *Forest Ecology and Management*, 236: 324-31.

Edwards-Jones, G., Plassmann, K. and Harris, I.M., 2009. Carbon foot printing of lamb and beef production systems: Insights from an empirical analysis of farms in Wales, UK. *Journal of Agricultural Sciences,* 147: 707-719.

Greene, WH., 2003. *Econometric analysis*. Fifth edition. Prentice Hall, New Jersey.

Hausman, J and McFadden, D., 1984. Specification tests for the multinomial logit model.

Econometrica, 52 (5): 1219–40.

Hausman, J and Wise, D., 1978. A conditional probit model for qualitative choice: Discrete decisions recognizing interdependence and heterogeneous preferences. *Econometrica,* 46: 403–26.

IACR (Inter Academy Council Report), 2004. Realizing the promise and potential of African agriculture. Royal Netherlands Academy of Arts and Sciences, NL-1000 GC Amsterdam: The Netherlands.

IPCC (Intergovernmental Panel on Climate Change), 2001a. Climate change: The scientific basis. http://www.ipcc.ch/

IPCC (Intergovernmental Panel on Climate Change), 2007. Climate change 2007: Synthesis report. Contribution of working Groups I, II and III to the fourth assessment report of the intergovernmental Panel on climate change [Pachauri, R.K and Reisinger, A. (Eds.)]. IPCC, Geneva, Switzerland.

Ishaya, S. and Abaje, I.B., 2008. Indigenous people's perception of climate change and adaptation strategies in Jema's local government area of Kaduna State, Nigeria. *Journal of Geography and Regi. Planning,* 1 (18):138-143.

Jones, J.W., 2003. Agricultural responses to climate variability and climate change. Paper presented at Climate Adaptation.net Conference Insights and Tools for Adaptation: Learning from Climate Variability, 18–20 November, Washington, DC.

Lautze S., Aklilu Y., Raven-Roberts A., Young H., Kebede G. and Learning J., 2003. Risk and vulnerability in Ethiopia: Learning from the past, responding to the present, preparing for the future. Report for the U.S. Agency for International Development. Addis Ababa, Ethiopia.

Maddison, D., 2006. The perception and adaptation to climate change in Africa. CEEPA. Discussion Paper No. 10. Centre for Environmental Economics and Policy in Africa. Pretoria, South Africa: University of Pretoria.

Maraseni, T.N., Mushtaq, S. and Maroulis, J., 2009. Greenhouse gas emissions from rice farming inputs: a cross-country assessment. *Journal of Agricultural Sciences,* 147: 117-126.

Mertz, O., Mbow, C., Reenberg, A., and Diouf, A., 2009. Farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel. *Environmental Management*, 43 (5): 804-16.

MoA (Ministry of Agriculture), 2010. Ethiopia's agriculture sector policy and investment framework: Ten Years Road Map (2010-2020). Draft Final Report 15 September 2010.

MoFED (Ministry of Finance and Economic Development), 2007. Ethiopia: Building on progress. A Plan for Accelerated and Sustained Development to End Poverty (PASDEP). MoFED, Addis Ababa.

Mohmud Yesuf, Di Falco,S., Ringler, C., Kohlin,G., 2008. Impact of climate change and adaptation to climate change on food production in low income countries: household survey data evidence from the Nile basin of Ethiopia. IFPRI Discussion paper No. 828. International food policy research institute, Washington, DC.

Nhemachena, C. and Hassan. R. 2009. Determinants of African farmers' strategies for adapting to climate change: *Multinomial Choice Analysis*, (2)1: 83-104

Nhemachena, C. and Hassan, R., 2008. Micro-level analysis of farmers' adaptation to climate change in Southern Africa. IFPRI Discussion Paper No. 00714. International Food Policy Research Institute. Washington DC.

NMSA (National Meteorology Service Agency), 2007. Meteorology report. NMSA: Addis Ababa.

Norris, E. and Batie, S., 1987. Virginia farmers' soil conservation decisions: an application of tobit analysis. *Southern Journal of Agricultural Economics,* 19 (1): 89-97.

Nyangena, W., 2007. Social determinants of soil and water conservation in rural Kenya.

Environment, Development and Sustainability.

O'Brien, K., L. Sygna, L. O. Naess, R. Kingamkono, and B. Hochobeb, 2000. User responses to seasonal climate forecasts in southern Africa; Report 2000:3, Center for international climate and environmental research: Oslo.

PCGCC (Pew Center on Global Climate Change), 2004. Coping with global climate change: The role of adaptation in the United States. PCGCC: Arlington.

Tizale, C.Y., 2007. The dynamics of soil degradation and incentives for optimal management in the central highlands of Ethiopia. PhD thesis, Department of Agricultural Economics, Extension and Rural Development, Faculty of Natural and Agricultural Sciences, University of Pretoria.

Tse, Y.K., 1987. A diagnostic test for the multinomial logit model. *Journal of Business and Economic Statistics*, 5 (2): 283–86.

Wegayehu Bekele and Drake, L., 2003. Soil and water conservation decision behavior of subsistence farmers in the Eastern Highlands of Ethiopia: A case study of the Hunde-Lafto area. *Ecological Economics,* 46: 437–51.

World Bank, 2003. Africa rainfall and temperature evaluation system. World Bank, Washington, DC.

Wu, J. and Babcock, B.A., 1998. The choice of tillage, rotation, and soil testing practices: Economic and environmental implications. *American Journal of Agricultural Economics,* 80: 494-511.

Table 1: Parameter estimates of the multinomial logit model for climate change adaptation decisions

Explanatory variables	Improved crop variety	Soil and water conservation	Adjusting planting date	Crop diversification	Combination of improved crop variety and diversification
	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients
Sex	0.014**	-0.812	-0.989	19.946***	-0.506
Age	0.020**	0.021**	-0.038	-0.019	0.0934**
Education	1.223	0.185	-0.468	0.888	0.324*
Family size	-0.067*	-0.143	0.147	0.0001	-0.088*
Distance to market	0.185	0.055**	0.095	0.107	-0.009
Livestock holding	0.015**	0.043**	-0.117	-0.026	0.0006
Off/non farm income	0.0004***	0.0004***	0.0004***	0.0005***	0.0001
Farm income	0.0002***	0.0002***	0.0003	0.0002***	-0.0085
Extension contact	0.0313**	0.0401**	0.0367	-0.0243***	-0.9802
Agro ecology	0.4934	1.4054	1.6584*	0.9411	1.0465*
Credit	0.4490	0.531	1.449*	0.3146	0.0631*
Farmer to farmer extension	0.0294	0.01949	0.0271	-0.0114	1.8317**
Access to climate information	-0.1215	1.2795	0.7457	-0.449	0.0394*
Land holding	-0.1837	0.2567	-0.0112	-0.3534	-0.5061
Diagnostics					
Base category	No adaptation				
Number of observation	160				
LR chi^2	152.37				
Log likelihood	-207.05				
Prob > chi^2	0.000				
Pseudo R^2	0.269				

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

Table 2: The marginal effects of the determinants of household adaptation decisions

Explanatory variables	Improved crop variety	Soil and water conservation	Adjusting planting date	Crop diversification	Combination of improved crop variety and crop diversification
	Marginal Effect	Marginal effect	Marginal effect	Marginal effect	Marginal effect
Sex	0.0694**	-0.186	-0.093	0.205***	-0.131
Age	0.005*	0.010**	-0.005	-0.0001	0.0018**
Education	0.320	-0.1387	-0.1795	0.008	0.456*
Family size	-0.0499*	0.0229	0.0268	-0.0008	0.0037
Distance from market	0.0256	-0.0159**	-0.007	-0.0007	-0.0059
Livestock holding	0.004**	0.0285**	-0.0241	-0.0005	-0.0056
Non/off farm income	8.85e-06***	-5.01e-06***	1.79e-07***	2.48e-06***	4.66e-07
Farm income	2.79e-06***	0.00001***	0.00002	1.35e-06***	0.00001
Extension contact	0.0005**	0.0023**	-0.0003	-0.002***	-0.001
Agro ecology	-0.158	0.1200	0.0582*	-0.0017	-0.0395*
Credit	0.0618	0.1454	0.1032*	0.0080	0.0087*
Farmer to farmer extension	-0.0008	0.0009	0.0015	-0.0013	0.0010*
Access to information	-0.2382	0.1932	0.0705	-0.0196	0.0268**
Land holding	0.0426	0.0194	-0.0326	-0.0264	0.0371

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