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Analysis on Determinants of Adaptation Options to Climate Change of Maize Smallholder Farmers in the South Eastern part of Ethiopia

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Abstract
This study focused on identification of perception level and determinant factors that influence some selected adaptation options to climate change on maize growing smallholder farmers in the South Eastern part of Ethiopia. Analysis of the study was based on cross sectional data collected through household survey data. Representative samples of 233 households were interviewed. Descriptive statistics and Multinomial logit equation model were employed to evaluate the level of perception of households on climate change, to identify types of adaptation options given priority by the local community, to examine determinant factors that influence the choice of farmers to employ adaptation options to climate change and to provide suitable policy implications on adaptation options to climate change. Results show that that about 86% of interviewed farm households perceived climate change as rise and hot in temperature and changing of the rainfall in quantity and timing. Econometric analysis result also reveals that; education level, age and gender of the household head, household size, land holding size and access to information have significant and positive influences on households' decision on employment of various adaptation options to climate change. The study also identified the most prioritized adaptation options by the households which include: soil conservation, off-farm works, fertilizers application, agro-forestry and use of improved seeds. Based on the findings, policies and strategies that encourage participation of farmers in planning and application of adaptation options with bottom-up approach is required for better climate change anticipation instead of focusing on reacting the impacts. This can be achieved through increasing access to credit facilities, comprising climate change in education policy, access to crop insurance schemes, improving agricultural extension system in view of climate change, enhancing farmers' organization for experiences sharing to strength public adaptation capacity, improving institutional capacity to generate climate information at local level.
Keywords: Adaptation, Climate change, Multinomial logit model, smallholder maize growing farmers, Ethiopia

INTRODUCTION

Climate change is a global challenge for both current and future generation of human beings and natural phenomenon. The definitions of climate change and related issues have broader significance than the terminologies themselves. Several literatures and experts have various definitions for the expressions; climate change, mitigation, adaptation and vulnerability. Among the others, IPCC (2011), defined; climate change is any change in the average daily weather pattern over extended period of time either due to natural variability or as a result of human activity. It is happening now and is already affecting many natural systems around the world. This occurrence resulted in global temperature rise and changes in rainfall variability with adverse impacts on the environment and natural phenomenon.

Adaptation is the ability of a system to adjust to climate change to moderate potential damages, to take advantage of managing the consequences. Mitigation of climate change is also a global responsibility in which human intervention aimed at reducing the sources or enhancing the sinks of greenhouse gases.

Whereas vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse affects of change of climate, including rainfall variability and extreme droughts. It is also a function of characters and rate of climate change and variation to which a system is exposed with its sensitivity and capacity. Currently climate change impact is a realistic experience of several countries of the world receiving enormous attentions. It is commonly accepted as a global issue that has significant effect on individual activities in general and particularly on the livelihoods of poor smallholder households.

Sub-Saharan Africa (SSA) countries for example, one of the regions that experienced the most severe impacts comes from climate change. It is significantly affect the livelihoods pattern and socioeconomic lives of majority of the people in the region particularly smallholder farm households in the agriculture sector. Ethiopia, one of the Sub-Saharan African countries is located in the horn with an area of 1.2 million square kilometer having diversified agro-ecologies with hot and arid to cold types of climate. Economically it is still in the category of developing poor countries of the world. This economic level besides to its geographical location made the country vulnerable to the adverse impacts of climate change and associated problems. As a result, climate change is a key policy issue of the country.

In Ethiopia, climate driven agricultural sector, cereal crop production plays great role as the means of livelihood of people both as home consumption and cash crops(MoFED, 2012).

Maize is one of the most important cereal crops, taking a major share of area cultivated and volume of production and the main staple food particularly for rural households of the country. Furthermore, diffusion of new technologies in Ethiopia has been more widespread for maize than other crops (Till et al., 2010). With subsistent farming system and traditional low input low output maize growing smallholder farmers in the central rift valley of Ethiopia are highly vulnerable to the impact of climate change. This is due to households' low adaptive capacity and high sensitivity of their socio-economic systems and challenges imposed to climate change through food security and natural resource degradation (NMA, 2012). Farmers living in such areas with erratic rainfall have different level of perception, attempting diverse adaptation strategies with various determinant factors of adaptation options. These problems need further study for policy instruments and betterment of the livelihoods of resource poor farm households. Land is one of the most important resources of the smallholder farmers in crop production. Productivity of the land as well depends on how to use the resource mainly considering usual use of adaptations to climate change. The challenges associated with climate change should be studied to ensure the livelihood of smallholder farmers able to integrate adaptation and mitigation practices in their day-to-day production activities.

Various studies on adaptation strategies to climate change have been done at regional and national levels in different countries. However, most of them are limited to the developed countries (IPCC, 2011) and not yet adequately addressed the problems that developing countries facing at household level in the agricultural sector. Most of developing countries are more vulnerable to adverse impacts of climate change from their low adaptive capacity. Sensitivity and adaptive capacity of the countries are also vary between sectors and geographic locations, time, social, economic and environmental considerations within a country (NMA, 2012). Although lots of research works on climate change are conducted globally, studies regarding adaptation options to climate change in Ethiopia have been recently done by different researchers (Ashenafi, 2011; Ermiyas, 2011). These studies are lacking clear information regarding perception level and potential determinants of adaptation options to climate change on specific to local and single crops like maize at farm-level. Majority of these studies are yet focused either on multiple crops (merged on one category) or at regional and national levels in the top-down approaches.

These approaches obviously overlook the possible adaptation strategies to climate change that smallholder farmers employing at household level on single crop. Similarly, none of them have looked perception level of smallholders and their determinants of adaptation options in view of specific crop at household level, what this study is concerned to address, and maize as focus crop in the central rift valley of Ethiopia. Therefore, it has a vital importance to identify the level of perception of farmers to climate change, prioritized types of adaptation options and determinant factors that influence the choice of households' adaptation options. Though, studies on impacts of adaptation options to climate change needs a continuous process on location specific response at household level it is not well identified yet in Ethiopia (NMA, 2007). In fact, much of information accessible on the adaptation strategies is limited to the macro level than at smallholder household farmers. Traditional farming practices and climate change associated problems in Ethiopia have threatened sustainability of agricultural production and its capacity to support poverty reduction. With different level of perception, smallholder farmers have responses against the adverse impacts of climate change.

However, lack of awareness of information on the main determinants and impacts of adaptation options to climate change can lead framers to use their scarce natural resources inefficiently and still could be a cause for climate change (emission of GHG). Unless these threats are well addressed, the future generation will be suffered more than the existing ones. In view of these facts, this study is designed to analyze the main determinants of adaptation options with regard to maize producing smallholder farmers of the central rift valley of Ethiopia, one of the most climate change vulnerable areas of the country. The hypothesis of this study is therefore awareness of smallholder maize growing farm households and employing different adaptations to climate change have positive economic effects on their livelihoods.

The Ethiopian central rift valley covers a variety of agro-ecologies characterized by extensive areas of low and erratic rainfall and limited areas receiving adequate rainfall (Jansen and Hube, 2011). Despite unpredictable rainfall, the region has a vital importance for the national food security through production of crops like maize, teff, haricot beans, sorghum etc. Moreover, analysis of the determinants of adaptation options to climate change from bottom-up approach has a vital importance to improve the livelihoods of poor households through improving their awareness and adaptation capacity. Moreover, maize is a staple food crop; its production is significant for the national food security and national gross product. Most literatures revealed that climate change have major impacts on farm revenue of agricultural production particularly on the smallholder farm households. However, none of these studies have attempted yet in Ethiopia to analyze determinant factors of adaptation options to climate change focusing on maize growing smallholder households. Furthermore, perception level of farmers on climate change in the area is also not well known. Hence, research works such as

this study, is important in order to provide appropriate information to policy makers that can improve farmers' effective capacity to adapt to the changing climate.

With this study therefore, it was intended to evaluate the level of perception of smallholder maize producing farmers towards climate change, major determinants of adaptation strategies of some selected adaptation options to climate change that enable them to reduce negative impacts on their livelihoods. The reason of the study to focus on smallholder farmers was due to their higher vulnerability to the harmful impacts of climate change, low adaptation capacity and their significant composition at the study area and national level. Various studies have been on the impacts of climate change on the Ethiopian agricultural sector analyzing the impacts on crop yield and identified some potential adaptation options. However, most of them have not identified factors that influence the choice of smallholder farmers to employ suggested adaptation strategies. Therefore, there is an urgent need for smallholder farm households and decision makers to know the most important factors that affect adaptation options to climate change on the farming practices. To increase understanding of the society particularly smallholder farmers, this study focuses on perception level and potential determinant factors that influence adaptation methods of maize farmers to employ at individual household level. Smallholder farmers in the central rift valley of Ethiopia are the most vulnerable to climate change impacts with low adaptive capacity (NMA, 2012). Therefore, this study tries to fill the knowledge gap of agriculturalists and decision makers by examining determinants of adaptation options and perception level of smallholder households on maize production with quantitative household survey data.

The study raised four main research questions to analyze adaptation strategies of the area; Firstly, which methods of adaptation options mostly employed in the area? Secondly, how farmers perceive climate change in their surrounding areas with agricultural activities? Thirdly, what are the determinants that make households execute adaptation options, and finally what policy measures are required to make the climate change to be sustainably increase productivity of farmers rather than its adverse impacts? These questions will be answered based on the following objectives by using some descriptive analysis and relevant econometric models

Therefore, the general objective of the study is to analyze the maize growing smallholder farmers' adaptation options to climate change and variability in the central rift valley of Ethiopia. Under this main goal, the study aims to pursue the following specific objectives:

- To evaluate the level of perception of households on climate change
- To identify types of adaptation options given priority by the local community
- To examine determinant factors that influence the choice of farmers to employ adaptation options to climate change
- To provide suitable policy implications on adaptation options to climate change

The data required for analysis was collected from smallholder maize growing farmers of Adama and Adami Tullu Jiddo Kombolcha districts through household survey. The finding of the study enables to generate essential information and appropriate policy options to employ efficient adaptation strategies.

Materials and methods

Study Area

The study was conducted in the central rift valley of Ethiopia one of the most climate change vulnerable areas of the country. Specifically the study was carried out in Adam and Adami Tullu Jiddo Kombolcha districts located in the Oromiya regional state in the central rift valley of Ethiopia The Ethiopian central rift valley is a part of Great African Rift located between 38000'-39030' east longitude and 7000'-8030' north latitude, it covers an area between the Yerer fault from the western edge and Abjiata Lake (Shashamane) on the southern side to Miesso on the eastern edge (FfE, 2010). The area is known with its potential of cereal crops characterized by semi-arid type of climate with erratic and low rainfall averaging between 500 and 900mm per annum (ATARC, 1998). Studies indicate that the rapidly growing of population has led to an increased demand of extensive utilization of natural resources in general and particularly arable land in the area. Hence, the demand for land area for agriculture is increasing very much as and the changing agricultural practices with the changed climate have increased pressure on the natural resources.

Adama and Adami Tullu Jiddo Kombolcha districts are known in their potential maize production with rain-fed dependent farming system. Adama district has a total area of 1008 km2 with a population of about 456,637. Whereas Adami Tullu Jiddo Kombolcha district have a total population of 178,204 with the total land area of 1275 km2The population density of the districts of Adama is 453 while for Adami Tullu Jiddo Kombolcha district is 139 persons per km2 (Getachew et al., 2010). The major crops grown in the area include maize, teff, sorghum, haricot beans and the main livestock in the area also includes cattle, sheep, goats, donkey and chickens.

Data Sources and Sampling Procedure

Primary data based on cross sectional survey was collected from a randomly selected 233 maize growing

smallholder households from Adama and Adami Tullu Jiddo Kombolcha districts of the Ethiopia central rift valley. A comprehensive questionnaire was prepared keeping the objectives of the study as a central point to collect necessary information. The questions were formulated to contain information regarding demographic characteristics of farm households (sex, age, marital status, level of education and family size), households' activities and income (occupation, farming behavior including land size and its use, agricultural inputs and outputs, livestock ownership non-farm income) and agricultural technologies (fertilizer, manure, chemicals, improved seeds etc) used. Matters relating perception and determinants of farmers in terms of sensitivity to climate change perception and adaptation options (frequency of drought, extent of the loss of yield of maize, main adaptation options preferred, determinant factors that influence adaptations) were also included in the questionnaire . Accordingly, the face-to-face interview took place from February to March 2013 at the home or in the village of smallholder farmers.Before execution of the main survey, pretest has been done by consulting socioeconomics researchers of Malkasa Agricultural Research Center (MARC) and agricultural offices of the districts. Pretest of the questionnaire has helped to check the consistency, duplication and clarity of questions and to plan the time and other required resources to execute the survey work on time.

The motives in this study to use the survey data, was to get relevant information directly from vulnerable farmers based on their recent practices and perception. Survey is an important method of data collection through face to face interviews and/or through well prepared questionnaires. As definition by Dooley (2003), a survey is a means of collecting information from a sample of target people by administering a questionnaire. Some of the advantages of survey are to make collected information more real, factual and detailed with close supervision of the researcher. In addition, it also helps to obtain more information through probing personal details, attitudes, past behavior and views of the respondents. Accordingly, the data collection was accomplished through close supervision of the researcher with six well trained enumerators, agricultural development agents and managers of respective peasant associations. Agricultural development agents and peasant association managers were participated in facilitating and providing the records of households and providing selected farmers for the interview. Besides the survey data, relevant secondary information was also collected from various literatures, agricultural offices, research centers and other related institutions.

Sampling Procedure

The study area, Adama and Adami Tull Jiddo Kombolcha districts of the central rift valley of Ethiopia was purposively selected in this study for; the area is characterized by extensive low and unpredictable rainfall and high extent of maize production in the area (Vilalta, 2010). Moreover, the existence of Melkasa Agricultural Research Center (MARC) and Adami Tullu Agricultural Research Center (ATARC) located in Adama and Adami Tull Jiddo Kombolcha districts respectively helps in access of providing different farming technologies to farmers as various adaptation options than other districts. In fact, the districts are not representative of entire central rift valley of Ethiopia as the area has diverse micro-ecologies, economic situation, cultural and political matters. Therefore, the selected districts represent mid and lowland potential maize producing farming system in the central rift valley of Ethiopia. To select sample households from the population, a two stage sampling technique was employed. In the first stage, potential maize producing peasant associations were identified from each districts based on information from the districts' agricultural offices. And then three peasant associations from these potential maize growing peasant associations of each district were selected randomly.

Accordingly, Adama district with a total of thirty six peasant associations six of them with 2490 households are potential in maize production which are located in the central rift valley of Ethiopia. From these potential peasant associations, three (Adulala, Merebe and Geldiya) were selected randomly for this study. Similarly for the case of Adami Tullu Jiddo Kombolcha, the district has forty three peasant associations and from these six of them particularly Bulbula area, the southern and south-eastern parts of the district are characterized as potential maize producers, with the total household number of 2116. Three peasant associations (Hurufa, Arba and Oda Anshura) were also randomly selected from these identified potential maize producer peasant associations. In the second stage, sample households (using probability proportional to size sampling method 30-45) were selected for the interview with systematic random sampling technique from each peasant association. Systematic random sampling procedure in this case is practical as the names of household heads' are available in the form of lists in peasant association offices. In such a design the selection process was done by picking some random point in the list and then every nth element was selected until the desired number of households secured. Such sampling method uses to solve the systematic bias, failure of sample to represent the population it was intended to represent (Kothari, 2004). The proper sample size for the household survey with a total population size of the two districts was 4606 (2116 of Adami Tullu Jiddo Kombolch and 2490 from Adama districts) smallholder maize growing households based on the information obtained from the peasant associations and extension agents. And finally a total of 233 households were selected from the specified number of population. The simple size determination was computed based on the formula developed by Cochran (1977) as follows;

$$n = \frac{(t)^2 * (p)(q)}{(d)^2}$$

Where; n = number of sample households
t = value for selected alpha level of 0.025 in each tail = 1.96 (the alpha level of 0.05 indicates the level of risk willing to be taken that the true margin of error may exceed the acceptable margin of error).
d = acceptable margin of error for proportion being estimated = 0.05 (error to be excepted)
(p)(q) = estimate of variance = .25 (taking possible proportion (0.5)*1 – maximum possible proportion (0.5) produces maximum possible size.

$$n = \frac{(1.96)^2 * (0.5)(0.5)}{(0.05)^2} = 384$$

Therefore, the sample size is greater than 5% of the population (4606*.05=230.3)which indicates that sample size is properly representing the population.

Table 1: Distribution of respondent households by districts and peasant association

District	Peasant association	Respondent households number	Percentages
Adama	Geldiya	36	15
	Merebe	45	19
	Adulala	45	19
ATJK	Hurufa	30	13
	Arba	41	18
	Anshura	36	15
Total		**233**	**100**

Method of Analysis
Both descriptive statistics and econometric models were used for analysis of the quantitative survey data collected from the two districts of Ethiopian central rift valley.

Descriptive Statistics
Descriptive statistics were used to characterize farmers' perception and their prioritized types of adaptation methods on climate change. Statistical instruments including frequency, percentage, crosstabs, and standard deviation was used to summarize collected data. In the data entry, computation, descriptive and econometric regression analysis, computer software EXELL, Statistical Packages for Social Studies (SPSS) version 16 and STATA version 11 was employed.

Econometric Model
The Multinomial logit model in this study was used for analysis of dependent variables that takes more than two values to investigate the major determining factors of selected adaptation options. The assumption behind this econometric model is that farmers' decision of any adaptation option is influenced by a variety of socioeconomic factors and farmers' perceptions about variables related to climate changes. Theoretical concepts and empirical studies indicated that factors influencing agricultural adaptations involve a mixed set of qualitative and quantitative data. Models normally used for examining relationships between qualitative dependent variables and mixed independent variables are qualitative response regression models (Green, 2002). In this study, Therefore, Multinomial Logit (MNL) model was employed to identify determinate factors that influence choice of farmers to employ adaptation options in the study area. Multinomial Logit Model (MNL) and Multinomial Probit (MNP) regression models are the two most important and commonly used analytical models for analysis of adaptation studies involving multiple choices. Both Multinomial Logit Model and Multinomial Probit models can be used interchangeably for analyzing farmers' adaptation decisions. For this study Multinomial Logit (MNL) model was used for analysis of determinants of households' decision to employ adaptation methods. The reason of using this model in this study was it's widely used in many fields than the probit model and its easiness for computation (Tazeze, 2012). However, the MNL model suffers from problems of lack of independence of

irrelevant alternatives (IIA), 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 (Creel, 2002).

Empirical specification of the Model (MNL)

Following Greene (2002) the general form of the multinomial logit model for this study was justified according to the following equations:

- Let y denote a random variable taking on the values {1, 2, . . .j} for choices j, is positive
- Let x denotes a set of conditioning variables

In this case, y representing the adaptation measures chosen by any farming household in the study area. Assume that each farmer faces a place of discrete, mutually exclusive choices of adaptation choices. Accordingly, a person chooses exactly one of the strategies and these measures are assumed to depend on factors of x. Therefore, x represents a number of climate elements, environmental and socioeconomics of households and other factors. The question here is how changes in the elements of x affect the response probabilities;

P(y = j/x), j = 1,2, . . . j Since the probabilities must sum to unity, p(y=j/x) is determined once with the probabilities for j = 2, . . . j. Let x be a 1xK vector with first element unity.

The multinomial logit model has a response probabilities:

$$P(y = j / X) = \frac{\exp(x\beta_j)}{1 + \sum_{k=1}^{j} \exp(x\beta_k)} \quad j = 1, \ldots, J$$

Where Bj is Kx1, j ==1 . . . . , ji

The marginal effects or marginal probabilities are functions of the probability itself and measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable from the mean (Tazeze, 2012).

Variables included in the model

The dependent variables included in the model are those adaptation options/strategies that were selected by respondent farm households of the study area to reduce possible negative impacts of climate change. The variables (dependent) are household characteristics and resources of the household that assumed to have most association with adaptation strategies of the household.

i. Dependent variables (Adaptation strategies)

Climate Change National Adaptation Program of Action (NAPA) of Ethiopia has identified about thirty seven potential adaptation options for Ethiopia (NMA, 2007). But for this study, adaptation options (dependent variables) were obtained from the smallholder farmers through survey questions, information obtained from agricultural research centers and agricultural development offices. The variables includes; off-farm work that the households engaged to get additional income out of agricultural activities, changing crop variety (using some of improved varieties released from agricultural research centers), changing crop technique/calendar (changing time of cultivation, harvesting and etc.), soil management and conservation, credit services, crop diversification, government assistances, agro-forestry and irrigation options.

ii. Independent (explanatory) variables

Different natural, socioeconomic, social, political, institutional and household characteristics are some of the factors influence farmers' preferences and ability to implement adaptation options to climate change. The explanatory variables from the survey data was; sex, age, education level of the household head, family size (number of people in a household), land holding size and occupation of the household head were found to be statistically significant.

RESULT AND DISCUSSION

Household Characteristics

i. Age of Household Head

The survey result indicated that the age of household head in the study area fall in the age range of 21-78 years old with average of 39.3 years and standard deviation of (12.5) most of them about 91% are male headed and the rest 9% households are female headed. In both districts, most farmers assume as old age associated with more experience and they expect older farmers are more to make adaptation to climate change compared to younger ones that have lower farming experiences. The age proportion of the family members in the study area was; children less than 14 years are 49.11 %, people with the age range in 15-64 years (usually active labor forces) are 49.04 % and above 64 years old are 1.85 %. This proportion of age indicates that almost half of the population was in the working age and the other 50% are dependent on the rest of the family members, child less than 14 years and the old above 64 (table 2).

Table 2: The age structure of the family in the households

NO.	Age category	Number of people in the households	Percentage
1	Children less than 14 years old in the family	716	49.11
2	People in the age range of 15 to 64 years	715	49.04
3	Household member above 64 years old	27	1.85
4	**Total**	**1458**	**100**

Source: Computed from own survey

ii. Educational Level of the Household

Education is one of the most important factors influencing decision of farmers to carry out adaptation options to climate change. Most of the farmers in the study area fall in primary education level including read and write (66%), no formal school (10%) secondary education (21%) while only (3%) of household heads have completed secondary education (table 3).

Table 3: Education Level Household Heads

Variable	Number of household heads	Percentage
No formal school	23	10
Primary education and read &write	153	66
Some secondary education	50	21
Post secondary education	7	3
Total	**233**	**100**

Source: Computed from own survey data

iii. Family Size of the Household

The farm households of central rift valley of Ethiopia are characterized by low-input and low-output agricultural productivity and small land holding. This could be from high population growth rate with fixed area of land. Population growth, therefore, increased pressure on the land and environment in the area. The survey data indicates that the family size of the sampled households varies from 1 to 20 with the average of 6.3, which is above the Ethiopian national average family size of 5. Generally, the basic socioeconomic characteristics of the population in the study area are summarized with mean and standard deviation in (table 4).

Table 4: Basic characteristics of interviewed the households

Variable	Mean	Standard Deviation (SD)
Age of the household head	39.39	(12.49)
Years of education	3.82	(3.44)
Size of household family	6.26	(3.16)
Gender of household (1=male, 0=female)	0.91	(0.33)

Source: Computed from own survey data

iv. Resource Ownership and Occupation

The main occupation of the households in the study area was rain-fed dependent agriculture farming. The major natural resources and important asset of the household is land for crop production and livestock grazing. The size of land also used as indicator of household's wealth in the community. However, the land holding size is getting low due to high rate of population growth. The average area of land holding for Adama and ATJK districts are 2.10 and 2.16 hectare respectively. Farm households generally own the land area varies from 0.25 to 10 hectare, of which 88% (0.2 to 9.5 ha) cultivated, 0.55% fallow, 2.62% grazing and the remaining 8.88% is used as homestead land (table 5). This indicates all farm households are smallholder and none of the households have more than 10 hectare in both districts. Being the households are owners of small land size, farmers forced to cultivate maize as mono-cropping techniques, farming practices of replanting a single crop year after year on the same plot of land. Literatures argue that mono-cropping can damage the soil ecology through depletion and reduction of diversity of soil nutrients. However, teff, haricot beans and sorghum are some of important crops

usually cultivated in the area and also used as crop rotation by few farm households. Though the role of maize takes the main concern for domestic food consumption, it is also use as cash crop for majority of households in the area. Some of households sell expected surplus or when they are certain that the next crop will give high yield as a major source of income. In Adama district, about 77% of income for the household was generated from maize, and Adami Tullu Jiddo Kombolcha district close to 68% of family income obtained from sale of cultivated maize. Its high value as a cash crop is due to its increased nation-wide demand, as well as higher prices offered for other food crop like teff and beans. Furthermore, some of households prefer storing the yield for a long time as means of saving as a risk management measure in case of low production in the following seasons due climate change.

Table 5: Land use of the study area

Land use	Area (ha)	Percentage
Cultivated land	443.63	87.96
Fallow land	2.75	0.55
Grazing	13.19	2.62
Homestead	44.81	8.88
Total land owned	**504.38**	**100.00**

Source: Computed from own survey

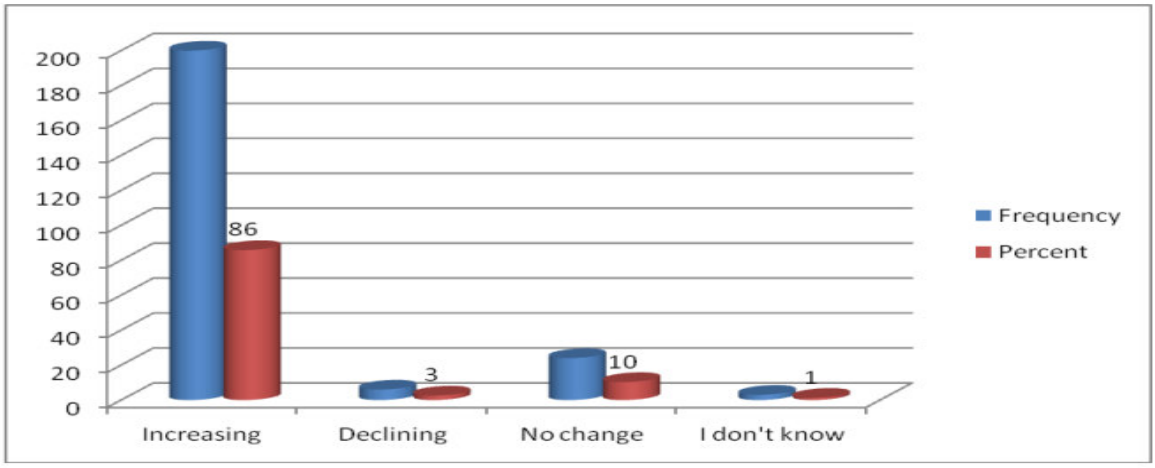
The central rift valley of Ethiopia is characterized as crop-livestock mixed farming system. In this farming system, most households have diversified sources of income which enables them to absorb weather shock during sever impacts of climate change. Potential sources of income for the households in the area include; non-farm, income from livestock, wage, own business, remittances, transfers and others. Besides income generation, livestock provides important contribution to the households as a source of nutrition, power for plowing (oxen) and means of transportation (donkey, horse and mule), manure for soil fertility. An average of livestock owned by households in the area is 4.309 TLU which is greater than the average of Ethiopia's dry land areas 4.0 TLU per household. This is an indication of the livestock resource as principal capital of smallholder farm household's as mixed farming with maize in the central rift valley of Ethiopia.

Perception of Farmers on Climate Change

Perception or having knowledge about climate change by a smallholder farm household is the starting point for attempting different local adaptation strategies to reduce harmful impacts of climate change. Most farmers in the central rift valley of Ethiopia, particularly smallholder maize growers have been affected by climate change in one or the other ways. Therefore, based on their perception level, socioeconomic and demographic factors households employ different adaptation strategies that they considered appropriate to reduce the impacts of climate changes and associated risks. As the survey result indicates, farmers in the central rift valley of Ethiopia have different magnitude of knowledge and exercise various adaptation options individually and as a community. Most of interviewed farmers have similar observation and describe climate change in terms of increasing in temperature and rain fall intensity and variability. Accordingly, 86%, 3% and 1% of selected farmers have noticed as change in the average temperature is increasing, decreasing and no change respectively. However, 1% of them have supposed as there is no change in temperature in their surrounding areas (figure 5). This indicates that the farmers in the study area perceived the existence of climate change.

The implication of the large numbers of households having awareness on increasing of temperature in the study area for the last ten years, was similar with the argument made by Jarraud (2011) which confirmed that over the last ten years from 2001 to 2010, the global temperature have increased on average by 0.46 oC above the 1961-1990 global average temperature.

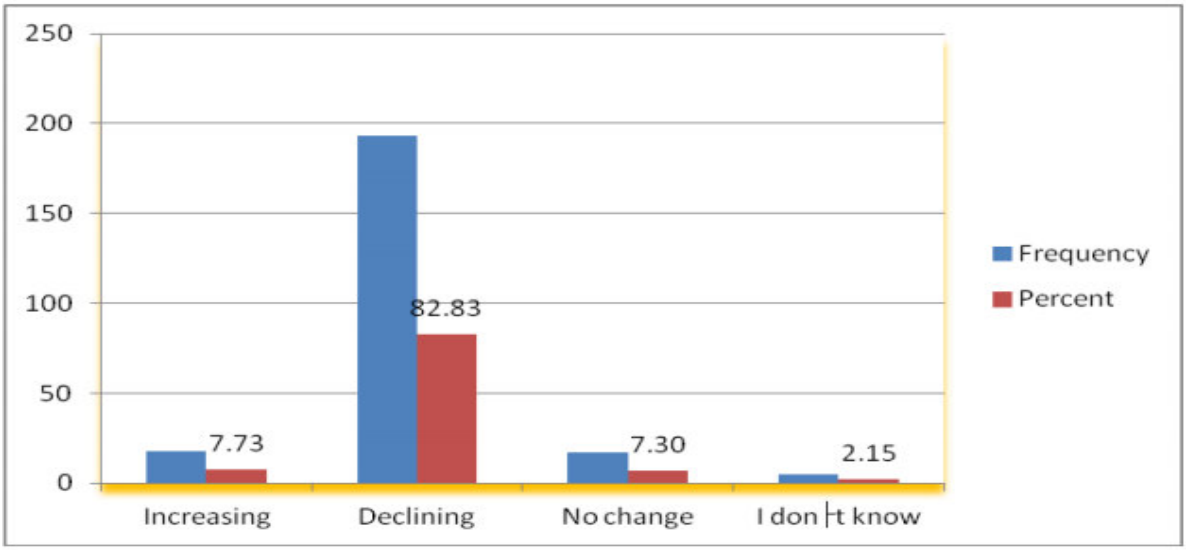
Figure 6: Household perception on the changes of temperature (percentage)



Source: Computed from own survey result

The response for the variability of rainfall (precipitation) level also indicates that 82.8%, 7.7%, and 7.3% of selected farmers also perceived decreasing, increasing and no changes on the level of precipitation respectively. On the other hand, 2.1% of selected farmers answered they do not know whether there is change in precipitation or not (figure 7). Generally, most of the households have better perception on climate change in terms of both temperature and rainfall variability. The survey data of this study indicates that farmers perceived as there is increasing in temperature and a decrease in precipitation in the Ethiopian central rift valley. This is true from some literatures that the two most important direct agricultural inputs of climate change variables in Ethiopia was becoming dynamic and unpredictable. Example, the National Meteorological Service of Ethiopia (NMA, 2007) showed that the average annual minimum temperature over the country has been increasing by about 0.250C every century and average annual maximum temperature has been increasing by 0.10C every ten years. Then, the rise in temperature and reduction and variability of precipitation level of the rainfall could be resulted in a negative impact of maize production and the livelihoods of the households.

Figure 7: Household perception on the changes of rainfall (percentage)

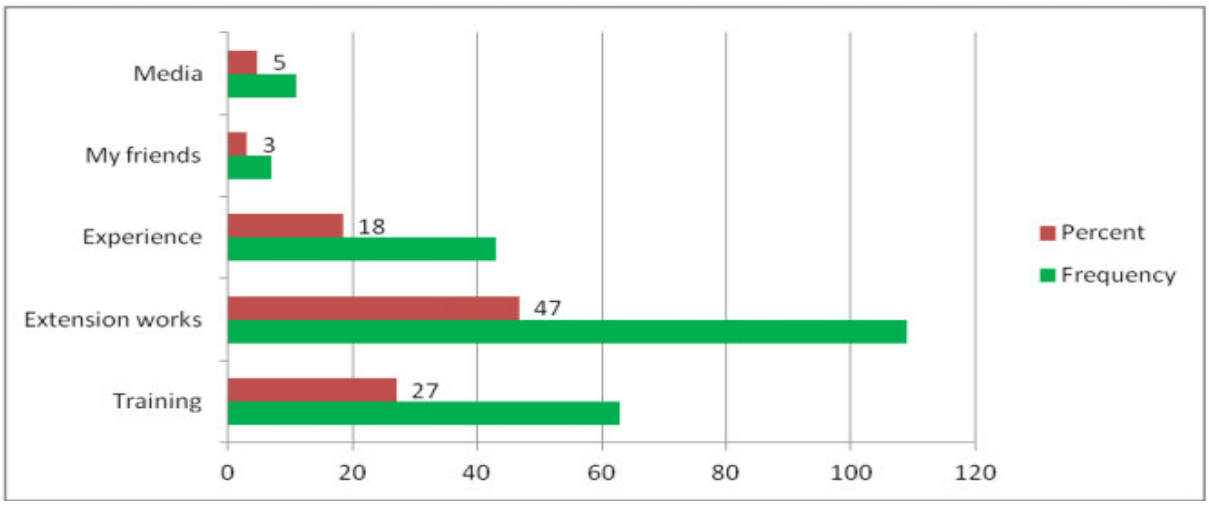


Source: Computed from own survey result

Sources of information

Households get information concerning climate change from different sources. As a result of the survey, about 27% of the interviewed farm households get information related to climate change and adaptation strategies from training provided by different stakeholders (agricultural offices, research centers, NGOs and others). About 47% of them get information from extension workers in their peasant associations. About 18% of farmers also get information from their own experience and the rest 3% from their friends or neighborhood farmers. Media such as television, local FM and national broadcasting radio programs are also a source of information for 5% of farm households as indicated in (figure 8).

Figure 8: Household's main sources of information regarding climate change

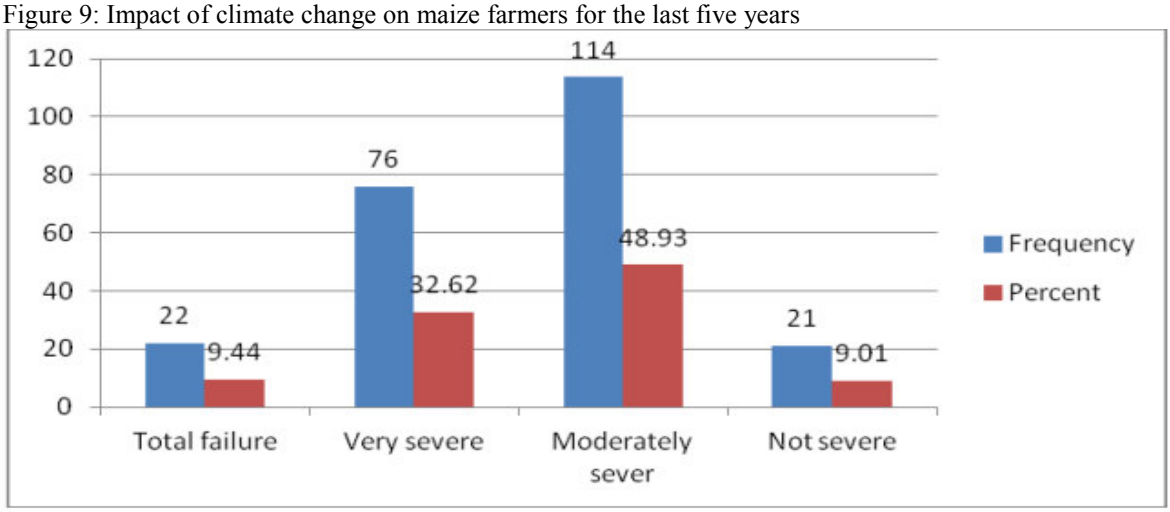


Source: Computed from own survey result

Perception on impacts of climate change

Most farmers have awareness on the level of maize yield failure due to climate change from their personal observation for the last ten years. The levels of perception of farmers have different ratios in terms the severity of the failure. Accordingly, 9.4% total failure, 32.6% vey sever, 48.9% moderately sever the rest 9% not sever of the yield failure as the impacts of climate change on productivity of the crop (figure 9).

Figure 9: Impact of climate change on maize farmers for the last five years



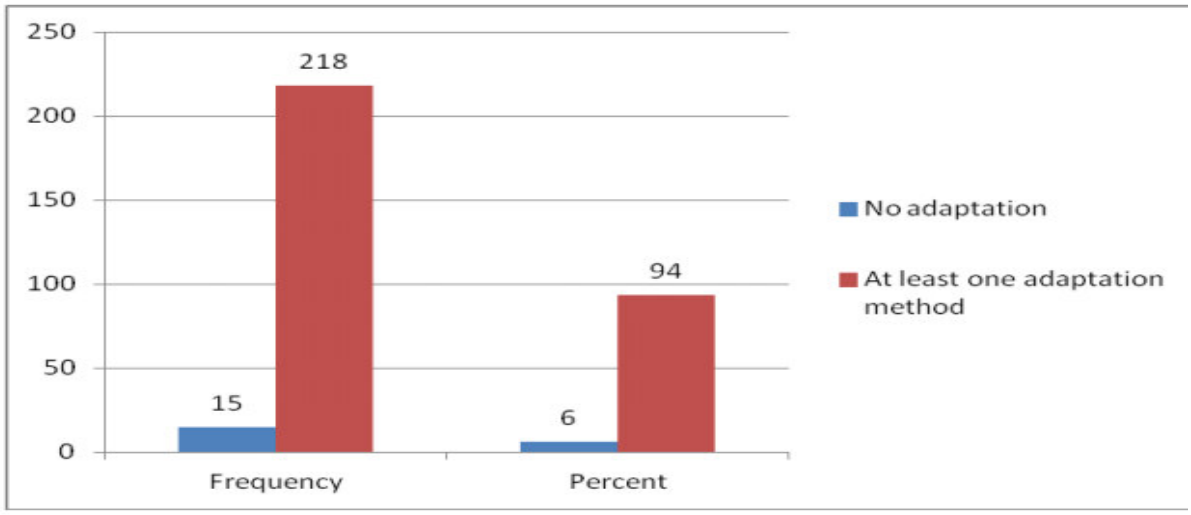
Source: Computed from own survey result

Prioritized Adaptation Strategies by Farmers

Though in Ethiopia, 37 potentials adaptation options identified by NAPA to address immediate adaptation needs for further prioritization and ranking (NMA, 2007), less of these adaptation strategies have been employed by smallholder maize growing farmers in the central rift valley of Ethiopia. Some of the most adaptation strategies used by farmers are evaluated in this study and analysis show that feasible and financially economical options have significant benefits over costs to be incurred to reduce the risks of negative impacts of climate changes. Majority of farm households in the study area have employed adaptation strategies that enable them to improve their livelihoods through diversification of sources of income and changing farming practices with modern technologies with utilization of improved agricultural inputs. As the survey result indicates, most of the interviewed farmers are dependent on rain-fed agriculture and had no irrigation facilities for maize production. In the central rift valley of Ethiopia no farm households yet employed irrigation system for maize cultivation. The study shows that farmers' adaptation decisions are affected by expected returns and cost to be incurred to use alternative methods. The level and type of adaptation was affected by economic resources and demographic factors of the households including age and educational level of household head, occupation of the household head, size of land, family size and ownership of livestock. In fact, most of adaptation options reported by households are not exactly come from the cause of climate change, but for improvement of yield of the crops. However, it is assumed that the experiences of farmers are driven from climate change factors, just as confirmed on the study by Maddison (2006). In general, 93.6% of interviewed farm households have employed one or more adaptation strategies to climate change in their farming practices (figure 10). The rest few farmers 6.4% have not

employed yet any adaptation options assuming that climate change is a concern of supernatural forces. These farmers are assumed as reluctant to use agricultural technologies rather than praying for supernatural forces as an alternative.

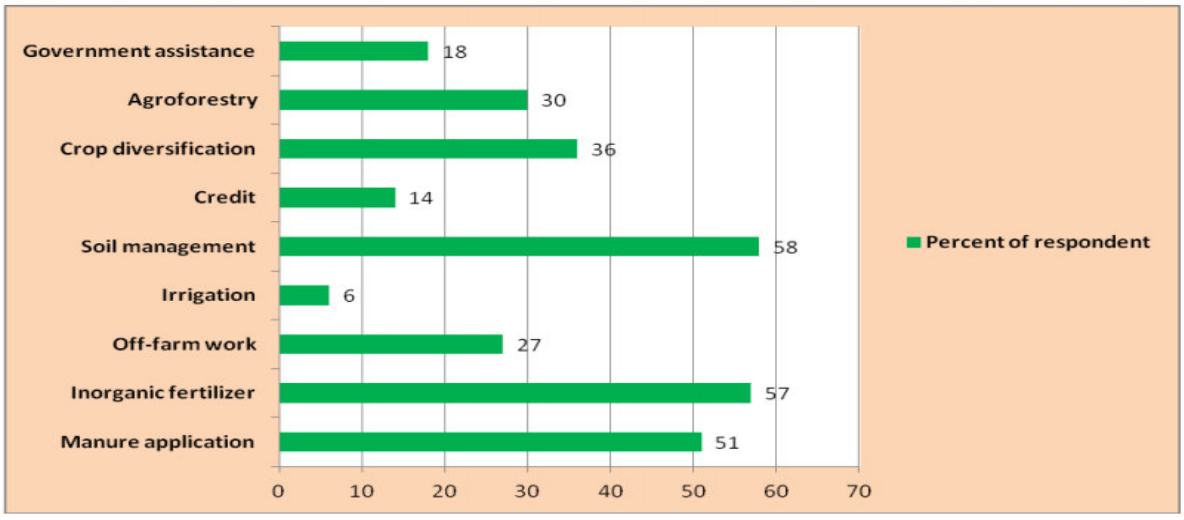
Figure 10: Ratio of farmers' level of adaptation options



Source: Computed from own survey result

Understanding of adaptation options of smallholder farmers help to identify and employ appropriate and feasible adaptation strategies of the area based on their specific site in the long-run. That means local level adaptation analysis contributes to create more sustainable and equitable production environment. In the study area, farmers have employed various adaptation strategies based on their perception on climate change. Major adaptation strategies prioritized in the area includes; application of synthetic fertilizer, manure, use of improved seed, off-farm works, soil management and conservation, crop diversification, irrigation (for horticultural crops), agro-forestry, credit and government assistance (figure 11).

Figure 11: Adaptation strategies of households



As indicated in figure 11, use of soil conservation and management is the most prioritized strategy of the households (58%), while irrigation is the least strategy used among the main identified adaptation strategies in the central rift valley of Ethiopia. The use of soil conservation with large people as adaptation option could be interrelated with the promotion and attention recently given by government at national and regional level as a campaign to meet the ambitious climate resilient green economy in the GTP. The lowest level of use of irrigation for adaptation in the area could be associated with limited access of water and suitable land by smallholder farmers. Other major adaptation methods are employed with in these lowest (irrigation) and highest (soil conservation and management) within the range of 14 to 57 percent.

Table 6: Households' adaptation strategies to climate change

No.	Adaptation practices	Number of household	Percentage (%
1.	Manure application		
	Yes	119	51
	No	114	49
2.	Inorganic fertilizer		
	Yes	132	57
	No	101	43
3.	Off-farm works		
	Yes	64	27
	No	169	73
4.	Irrigation		
	Yes	13	6
	No	220	94
5.	Soil management		
	Yes	136	58
	No	97	42
6.	Credit		
	Yes	32	14
	No	201	86
7.	Crop diversification		
	Yes	84	36
	No	149	64
8.	Agro forestry		
	Yes	71	30
	No	162	70
9.	Government assistance		
	Yes	42	18
	No	191	82
Total		**233**	**100**

Source: Computed from own survey data

Manure Application

As the summary indicated in table 6, about half of the interviewed farmers (51%) prefer manure application for maize production instead of the synthetic fertilizers. The reasons why farmers favor to use manure is easily availability and cheaper price than synthetic fertilizers. Practically all synthetic fertilizer used in Ethiopia has been limited to Di-Ammonium (DAP) and urea. Use of manure as opposed to relying on synthetic fertilizer enhances agro-ecosystem and increases organic matters that allow soil to capture and retain more water. Application of manure to the soil in turn reduces vulnerability to climate change extremes such floods and can also help to regulate soil erosion. Livestock is also the main sources of manure for smallholder farmers for those using mixed crop-livestock agricultural system. Livestock provides not only milk and meat, but also manure that can improve soil fertility. This can be considered as a best option of the types of linked strategies that fit well smallholder production system (Mowo et al, 2010).

Inorganic Fertilizer

Inorganic fertilizer is a type of crop production inputs widely used in agricultural sector to increase yield when applied with full recommendation given by soil researchers. As seen in table 6, about 57% of interviewed farm households use synthetic fertilizer to improve their adaptive capacity through increasing marginal productivity of land in terms of maize yield. Improvement of maize yield by inorganic fertilizer could be again resulted from increasing of essential macro-nutrient (nitrogen and phosphorous) to the cultivable soil. But contrary to manure, chemical fertilizers are potential cost to the GHG emission of CO2 (IPCC, 2011). Synthetic fertilizers used by farmers in the study area are urea and DAP, farmers using such fertilizer are claiming against increasing dependency on expensive external input since the soil is adapted to it and unaffordable price. Furthermore, farmers are claiming use of synthetic fertilizer for the yield getting decreasing because of similar rate they are using without consideration of soil change over time.

Off-farm Income

The sources of income of the households come either from farm or non-farm or both activities. Off-farm work would be an excellent income diversification option for many households of climate-vulnerable agricultural producers in the poorest regions of the world. However, most manufacturing industries having higher labor demands are available in towns far from the area of farm household is often costly and may require temporary migration of the family member from rural to be employed, thereby removing their contribution to the farm (Ivanic, 2008).

Therefore, non-farm income in addition to farm income can increase the likelihood of households' use more of adaptation strategies to climate change. In the study area, the most important off-farm activities include petty trading (trading of livestock and grain), wage income and own business income (e.g., cart driving), being employed by large scale public and private farms in the area (such as sugar factory for Adama and floriculture for Adam Tullu Jiddo Kombolcha) are some of potential sources of income for the households.

Irrigation

Even though, climate change affects water resource for use of irrigation, studies confirm that crop production with irrigation is positively affected by climate change than rain-fed agriculture if there is sustainable available water and suitable land. In both Adama and Adam Tullu Jiddo Kombolcha districts no onnonee of farmers use irrigation for maize production. However, irrigation is widely used in the central rift valley of Ethiopia for horticultural crop production. In this case only 6% of interviewed farmers have employed of irrigation as a potential adaptation option to climate change.

Soil Management and Conservation

Loss of fertility of the soil is a great challenge of farmers in crop production of the central rift valley of Ethiopia. Therefore, soil management and conservation is one of identified adaptation options for climate change. Such soil conservation and management strategies particularly in countries like Ethiopia have vital importance to withstand climate change associated problems of erratic rainfall and soil degradation (NMA, 2007). As the survey result indicates about 58% of selected households were employed soil management and conservation practices as adaptation option individually and jointly with the society. Actually, in recent time, soil and water conservation has got high consideration and priority by the Ethiopian government's growth and transformation plan.

Credit

Most farming households in the study area have low income and thus, have few or no saving tradition. Therefore, those farm households whom are not saving could be forced to seek credit from better-off persons, or formal and informal credit sectors during crop failure due to climate change. They also require credit to purchase inputs for maize production such as improved seed of maize varieties, chemical, fertilizers and others. Majority of farm households in the study area are not familiar with formal saving and access to credit services. But a most of households are getting informal credit from friends. Whereas, few of them can get formal credit from micro finance institutions like Oromiya Credit and Saving Association by organizing themselves as a collateral one for the other households.

Crop Diversification

Family labor and farm land are the two most important diversification opportunities of smallholder farm households. Family labor is the mobile resource to diversify activities and income generation outside of farming works while land is a fixed and limited resource of the family that is divided into different plots to cultivate various types of crops to spread risk of crop failure. In this study, crop diversification in terms of mixed cropping system is one of identified potential farm level adaptation options to climate change and variability. However, in the study area only 36% of respondent farmers moved towards crop diversification through production of vegetables and other horticultural crops on different plots of land. Furthermore, the households' farming system was characterized by mono-cropping farming pattern with of dominant maize cultivation.

The study also confirmed that the reason for less practice of crop diversification by the households was not only comes from their farming pattern but also from limited land size to cultivate different annual and perennial crops. This requires policy resolution through voluntary resettlement of landless farm households and family having large members to other area where extra land is available and ready for farming within the region. This policy option helps to ease population pressure on the land and environment. Though Ethiopia has a long experience on resettlement, its implementation needs further cost-benefit analysis of its impacts on the community and natural resources.

Agro Forestry

There are numerous households farming practices that can contribute to both a private benefit (adaptation to climate change) and a public good (mitigation of greenhouse gases). Agro-forestry, plantation of trees as agricultural crops is one of such prominent practices encouraged by policy makers and environmentalists. On one hand, Agro forestry play a vital role in mitigating climate change by reducing atmospheric accumulation of green house gas (GHG) through its capacity of carbon sequestration (Louis. et al., 2007). On the other hand, it

helps smallholder farmers adapting to climate change through changing unproductive marginal land to productive that can generate additional income. However, in this study only 15% of interviewed households have employed agro-forestry in the study area. This is due to small land size which is occupied for maize production and limited knowledge of efficient land management which needs policy intervention in appropriate land use management.

Government Assistance

Households of smallholder farmers usually rely on traditional risk sharing mechanisms of local social institutions such as (idir), credit from relatives and better-off individuals, "iqub" and other social networks. But, when adverse weather events affect the whole society and severe crop failure happens government subsidy is required. In the study area, even though there are no food aid dependent households, 18% of respondents were still highly vulnerable to climate change and they are in need of government aid for climate change related effects (for example as safety net program in Adami Tullu Jiddo Kombolcha district). The rest 82% of interviewed households use different adaptation options to climate change rather than relied on government aid and assistance.

Determinants of Adaptation Options to Climate Change

There are several evidences indicating that adaptation actions do not necessarily changed into end result, since adaptation strategies to climate change can be affected by other biophysical and social barriers making it local specific (IPCC, 2007). Smallholder farmers have limited capacities of adaptation options to climate change. Adaptation options based on indigenous knowledge of farmers incorporated with modern technologies are essential as inputs for policy makers to create appropriate and applicable policies which enable the society to reduce negative impacts of climate change. These adaptation strategies are affected by various local specific socioeconomics and family characteristic determinants. In this subsection therefore, estimation results of MNL model focusing on major determinant factors of farm-level adaptation strategies statistically significant at 5% was discussed.

Overall Performance of the Model

Multinomial logit model specification was used by different researchers (e.g. Deressa et al., 2009) to model adaptation options to climate change on smallholder farmers. The independence of irrelevant alternatives (IIA) assumption needs that the probability of using a certain adaptation method by a given household is independent from the probability of choosing another adaptation option. In this study for specification of the model, it was tested for the validity of IIA assumptions using Hausman's test with Stata 11 program. Finally, the test was failed to reject the null hypothesis of independence of adaptation methods to climate change. This implies that the model specification is appropriate to model adaptation options to climate change of smallholder farmers in the central rift valley of Ethiopia.

Adaptation options or response probabilities used for this study are; no adaptation, off-farm work, crop variety change, crop cultivation technique, soil conservation, credit, crop diversification, agro forestry, synthetic fertilizer application and use of manure.

Table 7: Parameter estimates of the multinomial logit model for adaptation decision

Explanatory	Off-farm			Variety change			Technique/calendar			Soil cons.			Credit			Diversification			Agro-forestry			Fertilizer			Manure		
Variable	Coef.	S.E	P-value	Coef.	S.E	P-value	Coef.	S.E	P-value	Coef.	S.E	P-value	Coef.	S.E	P-value	Coef.	S.E	P-value	Coef.	S.E	P-value	Coef.	S.E	P-value	Coef.	S.E	P-value
Sex	.529	.517	.307	.886	.443	.045	-.534	.444	.001	-.354	.420	.399	.369	.591	.532	-.112	.554	.045	-.784	.528	.137	-.706	.444	.112	-.636	.453	.160
Age	.011	.013	.398	-.019	.012	.117	-.008	.013	.501	-.007	.012	.567	.039	.017	.019	-.010	.013	.458	.001	.013	.924	-.021	.012	.085	-.018	.012	.140
Education	.029	.020	.146	-.032	.019	.097	.053	.021	.013	-.019	.018	.266	.017	.028	.531	-.048	.023	.039	.016	.018	.394	-.020	.018	.259	-.060	.024	.011
Occupation	.712	.282	.012	.307	.259	.235	.005	.247	.985	.467	.018	.143	.502	.252	.047	.437	.023	.069	.024	.018	.927	.094	.909	.998	.080	.234	.732
Family size	.004	.056	.042	.128	.054	.017	.023	.053	.659	.016	.049	.748	.127	.067	.056	.073	.052	.159	-.011	.052	.028	.007	.050	.883	.022	.050	.660
Land size	-.336	.158	.040	.019	.117	.873	-.023	.119	.849	.036	.113	.750	-.147	.940	.363	.238	.123	.013	.087	.118	.461	.255	.123	.038	.206	.117	.033

Diagnostic
Base category = No adaptation
Number of observation = 233
LR Chi square (52) = 221.475
Pseudo R_ square = 0.631
Log Likelihood = 273.941
Prob. > Chi square = 0.0000;

(*, **, ***, Significant at 1%, 5%, and 10% respectively)
Source: Computed from own data

Explanatory Variables

The study confirmed that adaptation options to climate change of the households are associated with their socioeconomic, family and institutional characters that mutually determine the ways in which the household come to a decision to choose or not the strategy.

Table 8: Description of independent variables

Explanatory variable	Mean	Standard deviation
Age of household head	39.27	12.5
Education of the household head	4.11	8.7
Household size	6.26	3.1
Gender of the household head (1=male, 0=female)	0.87	0.3
Farm size of the household	2.04	1.9
Livestock ownership (TLU)	4.31	3.6
Main occupation of the household head (1=farming, 2=employed, 3=business)	1.32	0.6

i. Sex of Household Head

Gender of the household head (being male) was significantly and positively associated with three adaptation strategies; change in crop variety, change in farming techniques like adjusting planting dates (calendar) and crop diversification at 5%, 1% and 5% significant level respectively. Being male-headed household have better likely for access to new crop varieties and accept diversifying crops with risk taking than that of female-headed household due to traditional matters which limits the social interaction of female and awareness on new agricultural technologies. This finding is agreed with the study by Admassie (2004), male-headed households are more likely to get information about new agricultural technologies and also carry out risky business than female-headed. Similarly, Deressa et al., (2010) revealed that male headed households can affect the household's capacity to cope with diverse impacts of climate change in their local areas.

ii. Age of the household head

Age of household head, the number of years of the household head can correspond to farming experiences of the family which could affect adaptation strategies to climate change. In this study, age of household heads was associated positively and significantly with credit services. This could be because of the older household head have better social net works which enables them to have more relatives and resources to be used as collateral to get credit services. This is because, in the study area and also nationally, only organized groups of people are able to get credit services from micro finances. However, age is negatively and significantly affects fertilizer application. Fertilizer application is a modernization symptom leads aged people to hesitate about the new technology while younger household heads more prefer the new technological inputs.

iii. Education of Level the Household Head

Level of education is the number of years spent by the household head and acquired grade of classes attained. Education has a positive and significant relationship with most of dependent variables; off-farm works, changes of farming technique, and manure application at 5%, 5% and 1% significant level respectively. The relationship shows that education increases the likelihoods of adaptation capacity of households to the adverse impacts of climate change. Educated farmers have better access to information to get more opportunities of adaptation methods. This result has conformity with other empirical evidences. Tazez (2012), for example, revealed that educated farmers are more likely to respond to climate change through employing best adaptation strategies based on their knowledge and motivation to accept new agricultural technologies. Similarly the study by Maddison (2006) revealed that education of the household head increases the likelihoods of adaptation to climate change.

iv. Occupation of the Household Head

In Ethiopia, where agricultural production is main source of income, risks that comes from socioeconomic and climate change necessitates diversification occupation for the smallholder farm households across different farm activities and non-farm works. However, majority of farmers in the study area are principally engaged on farming and few of them have additional job opportunities besides their farming practices. It is expected that households with additional profession can diversify their income and increase their capacity to do more adaptation options. Accordingly in this study, having other profession has a positive and significant effect on adaptation methods including off-farm work and credit similarly at 5% of level of significance. Although the dominant activity of the area is mixed farming (crop-livestock), households have a tendency to diversify to other

occupation through other family members who are in active labor force to non-farm works including wage employment, handcrafts, petty trading, cart driving, being employed as a government employee and others.

v. Land Holding

Farm (land) size of the household is significantly associated with different types of adaptation strategies of the households. Accordingly, land holding negatively affects off-farm work as an adaptation strategy at 5% level of significant. However, it is positively associated with crop diversification and manure application at 5% and 10% level of significant respectively.

The negative relationship of land size with off-farm work explains the fact that households having large farm size prefer to cultivate their own land instead of looking for other off-farm works. Households with small size of cultivable land seek other means of income generating jobs such as (off-farm work) to cope with the impact of climate change. On the other hand, households with larger area of land take risk to diversify different types of crops they grow and encouraged to apply manure to increase productivity of their plots of land and also to increase yield.

vi. Household Size

Household size is significantly associated with most of adaptation strategies due to more access of family labor. In this study also household family size have positive and significant relation with off-farm work, crop variety change and agro-forestry at statistical significance level of 5% all. By mobilizing active labor force of the family farm households have been employed labor intensive activities like plantation of different seedlings of trees as agro-forestry. These results are similar with some findings of the past researches. For example, the study done by Hassan and Nhemachena (2008) revealed that households having larger family number are expected to have more capacity to do various types of adaptation options than those with small family number. Usually off-farm work is one of important adaptation options broadly employed by individuals to reduce the adverse impact of climate change as far as opportunities accessible in the area. Policy measure needs to access some labor intensive agro-industries which could be employee large number of household members as off-farm work nearby their village.

CONCLUSION AND RECOMMENDATION

Conclusion

Climate change which is arising from effect of greenhouse gases trapping is not a problem of specific community or country; it is a global problem of the generation in which all nations are concerned as both cause and consequence. Existing literatures on the impacts of climate change on the Ethiopian agriculture quantified the problems in terms of monetary and crop yields recommended some important methods of adaptation.

Majority of households have sufficient observation on climate change in terms of increased in temperature, reduction in volume and unpredictability of rainfall, and also increased frequency of drought in their living areas. Their observation is therefore related with most literatures those verified the raising of temperature and erratic nature of rainfall as the major problems of global climate change impacts of these days.

Farmers those have awareness on the impacts of climate change have employed different types of local farm-level adaptation methods against the adverse impacts of climate change. However, some inappropriate farming practices can harm the soil and likely to be the case for climate change itself. This is indicates the two ways relationship of smallholder farmers with climate change. On one hand, they are potential causes of the climate change and on the other hand they are vulnerable for the impact of climate change. Therefore, the relationship between climate change and the livelihoods of smallholder farmers signify the importance of simultaneously employing of both mitigation and adaptation options to climate change in the area through incorporation of indigenous knowledge of farmers with improved agricultural technologies with bottom-up approaches

The reality that the communities are affected collectively to climate change calls for joint actions of coping strategies. However, the existing responses of farm households to the impacts of climate change are based on individual households' interests and adaptation methods with autonomous and uncoordinated manners. The key sources of the differences for the households to employ adaptation strategies separately come from various determinant factors. In this study, the most important identified determinant factors that influence the choices of households to employ adaptation options to climate change include; gender, age, educational level and occupation of the household heads and also family size and land holding size of the households. This is therefore an indication of the need of urgent and appropriate policy intervention to organize and coordinate the responses against climate change impacts which improve sustainability of environment and betterment of the livelihoods of society and future generation.

In fact, there are some governmental and non-governmental institutions mandated in coordinating and supporting farmers' adaptation and mitigation actions in the study area. Some of these institutions are agricultural development offices, agricultural research centers, farmers' cooperatives, public administration offices, NGOs, micro finances and others. These institutions are providing capital investment of infrastructures,

awareness creations; improved agricultural technologies credit services, and other important logistics for the farm households to reduce the possible adverse impacts of climate change. But still they are reacting in top-down approaches which were failed to bring the required change and results for climate change related problems demanding further research.

For example there are different institutions are providing various research findings and recommendations from agricultural research centers and known universities. However, the results of most researches are still could not solved the backward traditional farming system of smallholder farmers with changing climate. Maize growing smallholder households in the central rift valley of Ethiopia are still using similar recommendation rate of fertilizers and only two types (Urea and DAP) over the years. But the soil character is changing due to climate change and inappropriate farming practices indicate the need of updated soil based test fertilizer recommendation and use of other important types of fertilizers fit existing soil conditions.

Population pressure on the area is also one of the problems of the society and environment which reduces income and per household farm size. Land holding size of the households in the study area was still small ranging 0.25 to 10 hectare nearly 2 hectare per household on average whereas family size is large in average 6.3 greater than the national average family size of Ethiopia which is five persons per household.

This indicates that in the central rift valley of Ethiopia, number of family member increased but in contrast household farm size and carrying capacity of the environment decreased.

Finally, the growth of number of family per household with traditional farming system reduced the size of land holding resulted in food shortage.

In this case the smallholder farm households are in need of extra land to cultivate. This in turn brought them to cultivate more area of lands such as grazing, marginal land and forest plots by diminishing natural vegetation cover, soil quality and water resources leading to environmental degradation which could be a cause for climate change.

Recommendation

Policy interventions in the climate change response should focus on application of both mitigation and adaptation options through strengthening public and households capacities to reduce negative impacts. Household-level adaptation strategies should also based on improving sources of income of the households. These is possible through providing suitable policy atmosphere which enables farmers to employ improved crop varieties, soil and water conservation, crop diversification, agro-forestry and use of locally available manure and application of inorganic fertilizers with soil-test based and updated rate.

Public investments on irrigation development, voluntary resettlement and providing adequate extension services on climate change should be available for the farmers timely. Household size in the central rift valley is above the national average which needs policy intervention in terms of family planning to reduce the population pressure on the land.

The livelihoods of small-scale farm households are dependent on rain-fed agriculture and highly vulnerable to climate change impacts especially during crop failure from weather conditions. This is because of the absence of adequate saving and insurance facilities at shocking time. Saving for most of households is quite difficult since they are living subsistence life. Therefore, government should encourage them to save at the time of excess production in good weather time through providing financial centers and awareness creation about savings. In the absence of saving, credit facilities should be accessible to households through relaxing credit policies in such a ways that individual household can encouraged to borrow for purchase of improved agricultural inputs to increase their adaptive capacity to climate change.

Crop failure due to climate change is another challenge of the smallholder households of the central rift valley of Ethiopia leads the household government aid dependents. Though insurance does not reduce the real economic damages come from climate change, for such instant climate change impacts weather dependent crop failure insurance is required. Therefore, establishment of insurances for crop failure should be encouraged through farmers' cooperative as a sustainable policy alternative instead of providing aids after the problem happened.

Meteorological forecasting is another important and modern option to adjust cropping calendar which helps to reduce yield loss by climate change. The existing meteorological stations in Ethiopia are located at national and regional level. The crop calendar of majority of the farm households depends on their traditional experiences without considering of meteorological forecasting. This is because of the absence of local specific meteorological stations, luck of awareness by farmers and accuracy of forecasting. Therefore, government should establish local specific meteorological forecasting stations, early warning and awareness creation for the farmers to allow them better prepare against harsh weather conditions.

An autonomous and disaggregated reactive adaptation strategy of farmers should be organized and proactive approaches in line with the Ethiopian government's ambition to build the green economy. This can be possible through organizing small-scale farmers to improve awareness on the causes and consequences of

climate change to improve their adaptation capacity. Ways of organization can be based on group formation with government, NGOs and other developmental organizations (e.g. farmers' research group, model farmers group etc.) should be encouraged. Government should also support small-scale farm households through providing various adult education and training besides existing agricultural extensions. Education on climate change-related should not be limited only through agricultural extension agents focusing farmers but also should be included in the country's formal education curriculum to promote interactions of the generation. Based on identified determinant factors, decision makers should implement favorable policy environment which helps to improve the livelihoods of the households and sustainability of the environment in bottom-up approaches. Enhancing income of the households is also important to develop adaptation capacities through creation of off-farm employment opportunities in the rural areas

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