International Research Journal of Agricultural Science and Soil Science (ISSN: 2251-0044) Vol. 2(8) pp. 347-363, August 2012
Available online http://www.interesjournals.org/IRJAS

Full Length Research Paper

Econometric analysis of local level perception, adaptation and coping strategies to climate change induced shocks in North Shewa, Ethiopia

***[1]Gutu Tesso, [2]Bezabih Emana and [3]Mengistu Ketema**

[1]P.O.Box 160334, Addis Ababa, Ethiopia
[2]P.O.Box 15805, Addis Ababa, Ethiopia
[3]Haramaya University, P.O.Box 48, Haramaya

Abstract

This study was conducted to analyse the determinants of perception and adaptation to climate change. The study also examines the coping mechanisms followed by farmers in the aftermath of climate change induced shocks using a survey of 452 households in north Shewa Zone. A two steps process of Heckman model was used to analyze adaptation to climate change, which initially requires farmer's perception that climate is changing and then responding to changes through adaptation. The analyses of determinants of perception to climate change revealed that number of factors ranging from socio-economic to natural have contributed to the increase in perception level of farmers to climate change. Moreover, the determinants of adaptation conditioned on perception have shown that several programmatically important variables have affected the adaptation level of farmers to climate change. The result indicates that perception to climate change was the prime determinant for adaptation. on the other hand, farmers follow different coping mechanisms; where some of the coping mechanisms negatively affect the future development of the community and immediate recovery from climate change impacts. Thus carefully targeted programming should be made to enable farmers take those positive coping mechanisms and exercise those strategies that can boost their adaptation to the changing climate condition. In conclusion, awareness creation on climate change, facilitation of credit availability, investment on non-farm engagement, improve good mix of livestock holding, encourage adult education, dissemination of indigenous early warning information, diversifying crops to perennial trees, and improved frequencies of agricultural extension contact be made so as to ensure farmers well perceive climate change and then adapt to the changes.

Keywords: Perception, Adaptation, Coping mechanisms, Climate change, Heckman, and North Shewa.

INTRODUCTION

In the context of Ethiopia, the national economy is dependent on sectors that are vulnerable to climate conditions, such as agriculture, fisheries, forestry, and tourism. In the country, dry spells and droughts is more frequent, rain more inconsistent and torrential downpours heavier, all of which together increase the risk of soil erosion and vegetation damage through runoff. These coupled with shortage of improved technology, low technical know-how, and poor marketing system resulted in serious food insecurity and economic underdevelopment of the country. Higher temperature normally increases the evaporation of soil moisture; that in turn aggravates water stress. According to WVI (2011), the amount of arid and semiarid land in Sub-Saharan Africa is expected to increase by 5% to 8% by 2080; this aggravates the unfavorable land tenure situation in many parts of Africa.

Various parts of the country and the study location, North Shewa, in particular exercise volatility in rainfall and associated drought and flooding. Even though high rainfall variability and drought are not new phenomena in

*Corresponding Author E-mail: gutessoo@yahoo.com

Ethiopia, the widespread of public perception (Markos, 1997; Mulat, 2004) and scientific evidences in some part of the country (Ketema, 1999) relating these phenomena to climate change used to be very low. Floods, which have not been major problem in Ethiopia, are now becoming notable in many part of the country. For instance, in 2006 the eastern and south-western part experienced one of the most devastating floods in the modern history of the country (Woldeamlak and Dawit 2011).

In North Shewa, small-scale agriculture constitutes the backbone of the community's lives. Rainfall variability and associated extreme events like droughts, flood, disease outbreaks, pests, etc have triggered serious problems. Literature reveals that even though rainfall variability and the associated shocks like drought and flooding are not new phenomena and the public perception is also improving, there is no sufficient evidence as to whether or not climate change is perceived as a major problem or reality among small holder farmers, particularly by the poor and most vulnerable farmers in the rural areas (Woldeamlak and Dawit, 2011). As far as published materials covering climate change perception and adaptation are concerned, only few studies (Mezw-Hausken, 2004; Mahmud et al., 2008; Akililu, 2009; and Deressa et al., 2008) have attempted to address level of perception to decrease in rainfall and increase in temperature.

In the world of frequent climate change, studies indicate that Africa's agriculture which is negatively affected by climate change (Pearce et al., 1996; McCarthy et al., 2001) needs to adapt to the changing conditions. As quoted by Deressa (2008), adaptation is identified as one of the policy options to reduce the negative impact of climate change (Adger 2003; Kurukulasuriya and Mendelsohn, 2006). Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC 2001). The major basis of adaptation needs to be a well perceived change and expected changes to come. In this regard, common adaptation methods in agriculture can include: use of new crop varieties and livestock species that are more suited to drier conditions, irrigation, crop diversification, mixed crop livestock farming systems and changing planting dates (Bradshaw et al., 2004; Kurukulasuriya and Mendelsohn, 2006; Nhemachena and Hassan, 2007).

Except the few qualitative attempts made so far by Woldeamlak and Dawit (2011), and quantitative analysis by Deressa (2008), there has been no study undertaken in Ethiopia to analyze factors affecting the perception and adaptations to climate change. However, any policy and development strategy that attempts to boost farmers' adaptation to the changing climate should be based on farmers' level empirical evidences. Recent studies suggest the need to focus on adaptation research that seeks to investigate actual adaptations at the farm level, as well as the factors that appear to be driving them (Smith and Lenhart, 1996; Brklacich et al., 1997; Belliveau et al., 2006; Maddison, 2006). Based on this need, the objective of this study is to analyze the factors that determine perception and adaptation to climate change. The paper also analyzes the different coping strategies followed by individual households in the aftermaths of any climate change induced shock.

METHODOLOGY

The study area

The study area is North Shewa Zone of Oromia regional state. North Shewa Zone is found in north-west direction of Addis Ababa with Fiche as the capital of the zone located almost at 147 Kms away from Addis Ababa. The zone has 13 rural districts with a total land area of 10,322.48 square-kilometers. It is situated between $9^0$30N and $38^0$40E. The topography of the area is mostly mountanious and ragged terrains and the altitude of the area ranges between 1300-2500 meters above sea level. The sone is divided into three agro-ecologies, namely, 15% *Dega* (Highland), 40% *Weyna-Dega* (Midland) and 45% *Kolla* (Lowland) (CSA 2007). The area gets rainfall during both *Belg* (February to April) and *Meher* (June to September) seasons. The average annual rainfall of the area ranges from 800 mm to 1600 mm while the mean annual temperature varies between 15^0C and 19^0C.

The population of the zone is estimated to be 1,431,305, with population density of 138.66 per square km and average of 4.56 persons to a household. The community practices mixed farming. The average land holding of the household is 1.1 hectare. Cereal crops, pulses and oil crops are grown in the area. Livestock production also constitutes an important part in agriculture of the district. Due to the continuous reduction of farmland to degradation by frequent flooding and drought, out of the zone's total area, 81% is brought to be farmland by expanding it to steep sloping areas, clearing forest lands, expanding to marginal lands and communal lands. Only 3% is grazing land, 3.7% forest land, 11.33% degraded and bare land and 0.65% is other form of land. The crops, livestock and other livelihoods of the community is subjected to damage to climate change induced hazards. This coupled with the continually decreasing farm size have serious impact threatening farmers adaptive capacity and livleihood improvements (CSA 2007).

Data and Analytical Tools

The data for the research was obtained from the survey of 452 farm households in three districts of North Shewa

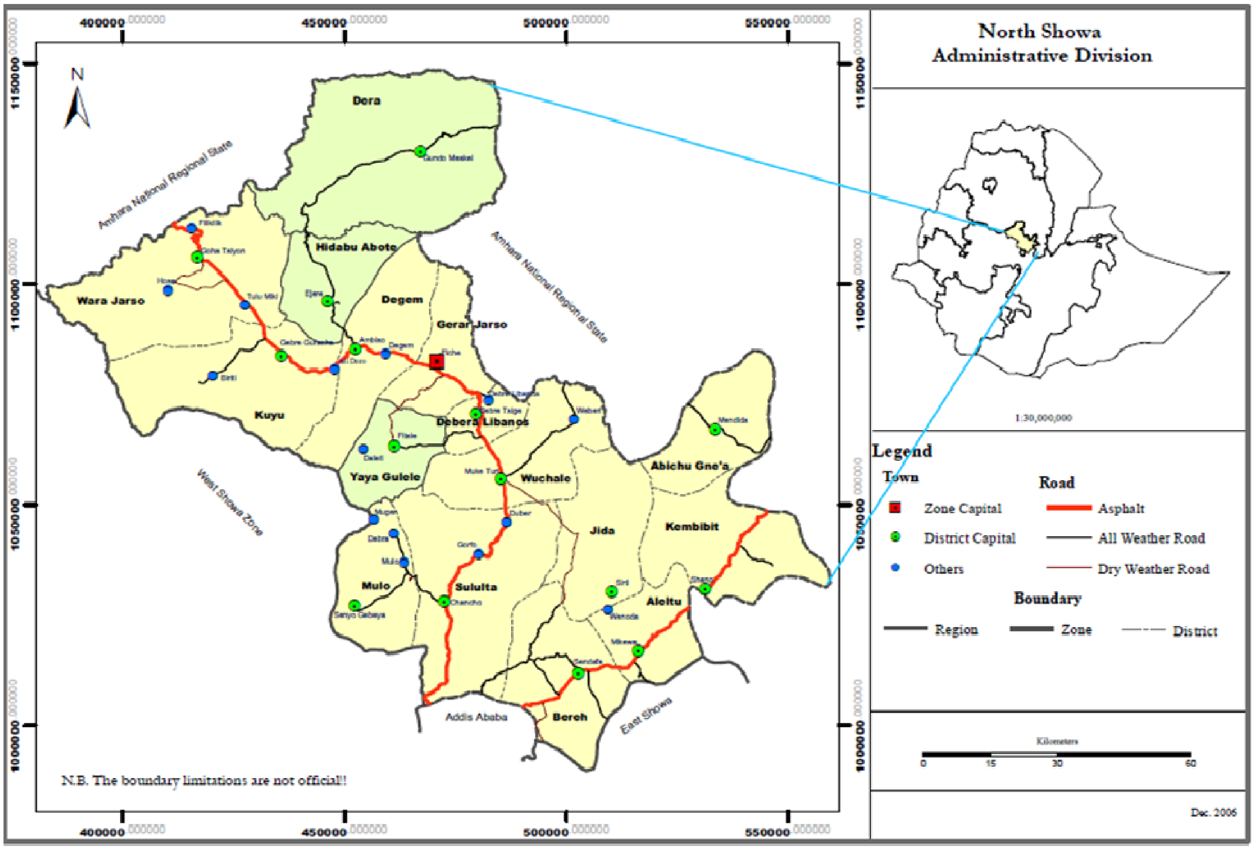

Figure 1. Map and location of North Shewa Zone: the first part of the map is north Shewa with its districts and the second part is Ethiopia with its regional setting.

Zone in 2011/2012. The districts included in the survey were Yaya Gullel, Hidha Abote and Derra districts. The specific study sites within the districts were selected based on a multi stage random sampling procedure. Consequently, 18 Kebeles were selected. Interview of household heads were conducted at a time convenient for the heads. A structured questionnaire was used to interview the farmers. Data collected from the farmers include household characteristics, landholding, crops and livestock production, disaster occurance, perception level (on percipitation, temprature, soil moisture, air moisture and wind direction), adaptation stategies pursued, different coping strategies pursued, level of resilience, and other relevent information.

In addition, the research employed review of secondary data at zonal level. The secondary data relevant for this analysis was obtained from the National Meteorological Service Agency (NMSA), Central Statistical Authority (CSA), and Zonal and district annual agricultural production and extension reports/data. In order to enrich the studies with more relevant information, qualitative household survey was also carried out. The qualitative data was collected through focused group discussion based on a checklist prepared for the purpose.

Model Specification

In order to identify and analyse the determinants of households' perception and adaptation to climate change, Heckman's two-step procedure was used for the anlysis of perception and adaptation. Adaptation to climate change involves a two- stage process: first perceiving change and then deciding whether or not to adapt by taking a particular measure. This leads to sample selectivity problem since only those who perceive climate change will adapt, where as we need to infer about the adaptation made by the agricultural population in general, which implies the use of Heckman's sample selectivity model (Maddison, 2006).

The argument behind conditioning of adaptation on perception follows the works of Deressa (2008), Maddison (2006), Mahammed et al. (2008), Woldeamlak and Dawit (2011), where they have presented that perception comes first to adapt to climate change and adoption of improved technologies. Thus, the hypothesis of this research was that farmers who perceive well about the changing climatic condition adapt to the situation very well through adoption of different adaptaion options.

Heckman Two Steps Procedure

Sample Selection Equation

Perception to Climate Change

The sample selection equation address the perception to climate change. In the sample selection, perception is a dependent variable where age, sex, educational level, HH size, extension services, market distances, number of relatives, farmer-to-farmer extension, irrigation usage, technology (improved seed), agro-ecology, ownership of radio, number of rural institutions participated in, number of non-farm enterprises, indigenous early warning, formal early warning, and training/awareness raising on climate change were the independent variables. Perception involves classification of respondents into two categories namely; perceived or otherwise. The identification of perception level was set in the questionnaire, where by a respondent's level of perception from his/her explanation of the change happening in terms of rainfall levels and variabilities, temprature change, wind direction and others were divided into perceived or not perceived. When including into the model, two important variables; rainfall and temprature was considered, in which case farmers who have correctly perceived the direction of change for temprature and rainfall were given 1 and the rest 0.

Therefore, the selection equation is binnary in which case we used binary probit model given as:

$$Pr(S_i = 1/Z, \alpha) = \Phi(h(Zi,\alpha)) + U_{1i} \qquad (1)$$

(sample Selection Equation)

S_i is the latent level of utility the household get from perceiving the climate change

Z_i is a vector of factors affecting perception of climate change

α is a vector of coefficients to be estimated

U_1 = the error term assumed to be distributed normally with a mean of zero and a variance of σ^2

Φ Standard normal cummulative distribution function

The latent Regression Equation: Adaptation to Climate Change Model

The latent regression equation, which was adaptation to climate change, was formulated by being conditioned on the sample selection equation. In the adaptation model the dependant variable was adaptation to climate change. The model specification for the second stage (adaptation) equation is as follows:

$$E(Y_{i.} / S_i = 1) = f(x_i, \beta) + \gamma_i \frac{\phi(Z_i\delta)}{\Phi(Z_i\delta)} \qquad (2)$$

E is the expectation of taking adaptive actions; Y_i is the (continuous) extent of adaptation to climate change, X_i is a vector of independent variables and β is the vector of the corresponding coefficients to be estimated

γ was estimated from the sample selection equation (Equation 1) using S_i and Z_i from whole sample and then the inverse mills ratio λ was computed as follows

$$\frac{\phi(Zi\delta)}{\Phi(Zi\delta)} = \lambda \text{ (the inverse mills ratio)} \qquad (3)$$

$$\gamma_i = \lambda_i(\lambda_i - Z_i\delta) \qquad (4)$$

ϕ the normal probabilit y density function

By entering the inverse Mills ratio to the adaptation equation, it can be rewritten as follows:

$$Y_i^* = X_j^1\beta + \gamma_i\lambda + U_{2j} \qquad (5)$$

U_{1i} ~ N (0,1) from equation 2
U_{2j} ~ N (0,1) from equation 5
Corr (U_{1i} and U_{2j}) = ρ

Where, X is K vector of regressors which included the following: household characteristics (age, sex, educational level), land size, labor, livestock ownership, extension services, credit services, income level, diversity of income sources, availability of perennial crops, market distances, relatives, farmer-to-farmer extension, irrigation, technology, crop diversification and other farm characteristics. In addition, an inverse Mills ratio from the perception model was entered into the model. Y_j^* is the dependent variable, which in this case is adaptation. Based on the 19 different adaptation options adopted by farmers, farmers were given value between 0 and 1, by dividing the number of adaptation strategies they have adopted by 19. For instance a farmer that has adopted five strategies will be given a value 0.263, computed as 5 divided by 19.

Therefore, climate change perception (Equation 1) and adaptation strategies (Equation 5) were jointly estimated by full maximum likelihood using the *Heckman* procedure in STATA. Thus, this provides consistent, asymptotically efficient estimates for all parameters in such models (StataCorp2003).

RESULT AND DISCUSSIONS

Perception to Climate Change and Its Impacts

Farmers' perception level

The major areas of focus in the instrument design for field

Table 1. Percentage of people having perceived change in climate parameters.

S/N	Climate change indicators	Percentage of respondents			
		Increased	**Decreased**	**No change**	**I don't know**
1	Belg rain	2	71	26	0
2	Meher rain	7	46	47	0
3	Temperature	70.6	21.2	3.5	4.6
4	Soil moisture	10	79.2	10.8	
5	Air moisture	7.7	87.8	4.5	
6	Wind direction change	Change (91.4)	No Change (8.2)	Not Observed (0.4)	

Source: computed from houshehold Survey

data gathering was that the survey instruments fully captured how farmers' perceive the change in climate parameters over range of 20 – 30 years and their approaches to adaptations. The perception of farmers to climate change indicate that most of the farmers in North Shewa were aware of the fact that *Belg* rain is failing, *Meher* rain is decreasing, temperature is increasing and the wind direction and speed is changing from time to time. To get information on their perceptions to climate change, farmers were asked sets of questions around rainfall, temprature, wind, soil mositure, croping shifts, etc. The first step involved asking farmers as to whether they have observed significant change on the above variables over the course of two or three decades. The second involved as to whether farmers have observed impacts of the change in these climate variables on crops, livestock, human health, natural resources, and the way they undertake their normal livelihoods. The responses from the farmers were in line with the report and data collected from the National Metrological Services Agency (NMSA 2012), which depicted an increasing trend in temperature, decreasing trend in precipitation, increase in crop and livestock damage, increased number of people affected, and changing croping dominance over time.

According to the analytical result from the household survey, about 70.6 percent perceived mean temperature as increasing over the past 20 to 30 years; 21.2 percent, as decreasing; and 8.1 percent, has either not observed or observed it as remaining the same. Similarly, only 2 percent perceived mean annual *Belg* rainfall as increasing over the past 20 to 30 years; while 71 percent, perceived that it has declined; and 26 percent perceived as remaining the same. In addition, the perception to *Meher* rain, indicate that while only 7 percent perceived its increase, the large majority as 46 percent and 47 percent, respectively, perceived it as decreased and no change. On the other hand, farmers' perception to the change in soil moisture indicate that 79.2 percent have perceived it has become more dry and 87.8 percent perceived air moisture has significantly decreased over years. As to the change in wind direction 91.4 percent have perceived change in wind direction. Table 1 above summarizes farmers' perceptions of climate change in the study sites. In general, farmer's have high level of perception for the serially increasing temperature and significantly declining precipitation in the study sites.

According to the data obtained from the CSA, for the period between 2002 to 2011, more than 3 million people were affected and nearly 60,895 hectares of crop lands were damaged to a range of climate change induced disaster. In line with this, it was found pertinent to enquire from the farmers to how many climate change disaster they were exposed to and their level of perception to these disaster as a climate change induced ones. Accordingly, the various hazards, directly or indirectly related to climate change, identified by the respondents were presented in Table 2 below. According to the rank given by the farmers, large majority of the farmers suffer from disease outbreak, untimely rain, severe land degradation, flooding, and drought.

According to International Panel on Climate Change (IPCC) (2007a), individuals or regions vulnerability depends on their adaptive capacity, sensitivity, and exposure to changing climatic patterns. Unprepared farmers due to low level of perception to climate change suffer to the level of losing their coping capacity. Witnessing to this fact, the situation of the study area shows the level of livelihood damage to natural events mounts up to 75% at times. For instance, the area stood to be the first at national level in Yellow rust outbreak that seriously affects the production of main enterprise. During the year 2008, farmers have lost nearly all of their production to drought and disease outbreak. According to the data collected through household survey, around 86.5%, 61.1%, 70.8% and 58.2% of the households have suffered from crop damage, loss of access to food, loss of income sources and damage of livestock production due to the change in climate change impact. Farmers' level of perception in associating these impacts to climate change was observed to be very high.

Determinants of farmers' perception to climate change

In the perception model, which was sample selection equation it was hypothesized that household characteris-

Table 2. Types of climate change induced disasters encountared by farm households.

S/N	Climate change induced disaster	Percentage of respondents affected	Rank
1	Drought	85	6
2	Flooding and excessive rain	36.9	5
3	Untimely rain	54.8	2
4	Wind storm	36.5	4
5	Crop and livestock diseases	63.5	1
6	Human disease	39.4	10
7	Insect outbreaks	32.7	9
8	land degradation	36.5	7
9	land slides	19.9	8
10	hail storm	64.8	3
11	Conflict	16.4	11
12	Others	7.3	12

Source: computation from household survey

Table 3. Level of climate change impacts on households' livelihood.

S/N	Climate change impacts at farm level	Percentage of respondents	Rank
1	Damaged Crop production	86.5	1
2	Damaged Livestock production	58.2	4
3	Affected livestock health	63.1	6
4	Affected human health	51.1	7
5	Has affected access to food	61.1	2
6	Affected income source	70.8	3
7	Resulted in livestock death	45.6	5
8	Resulted in human death	23.8	8
9	Others	11.3	9

Source: computation from household survey

tics, economic characteristics, social capital, agro ecological setting (highland, mid highland and lowland) and technological access would significantly determine the perception level of farmers to climate change. This hypothesis was in line with the works of Deressa (2008), Isham (2002), and Mengistu (2011).

Table 4 below presents the basic description of the variables included in the selection equation. Accoding to the responses given by farmers, large majority as 76.3% have indicated that they have perceived change in climatic variables, where as 23.7% have not correctly perceived the direction of change in important climate variables. The Table also provides detail statistical description of the independent variables which were assumed to affect perception to climate change.

In the analysis of factors determining farmer's perception level to climate change, it was hypothesized that, education, age of head of the household, involvement in non-farm incomes, exposure to any awareness creating meetings on climate issues, access to early warning information, frequency of extension contact, farmer to farmer extension, number of relatives in the village, participation in different local institutions and agro ecological settings significantly infulence the awareness of farmers regarding climate change. The case of information on climate change from either extension agents or any other organization is self-explanatory in that it was meant to create awareness. In this thought, farmer-to-farmer extension, participation in local institutions and the number of relatives in the village represent social capital. In technology adoption studies, social capital plays a significant role (Isham, 2002), in information exchange, and hence, it was hypothesized that more social capital is associated with higher level of perception of climate change. Moreover, farmers living in lowland areas were hypothesized to have perceived climate change as compared to midland and highlands. This is due to the fact that lowlands are already hotter and a marginal change in temperature could be perceived easily.

Model output for the sample selection equation

The model outputs from regression indicated that most of the explanatory variables have significantly affected the

Table 4. Description of model variables for the Heckman probit selection model.

S/N	Independent Variables	Maximum value	Minimum value	Mean	Standard Error
1	Age (in years)	90	18	46.7	15.04
2	Sex (1 male and 0 female)	1	0	-	-
	- Male respondents (380				
	- Female respondents (72)				
3	Educational level (in Years)	12+3	0	0.97	2.15
4	HH Size (in Number)	14	1	6.44	5.04
5	Distance to Market (in Hours)				
6	Number of relative	1000	0	56.59	76.24
7	Frequency of Extension Service (in A year)	40	0	3.2	2.027
8	Farmer to Farmer Extension (1 for those having F to F extension 0 otherwise)	1	0	0.316	0.465
	- %age HHs having of farmer to farm Ext (68.4%)				
	- %age of HH having no farmer to farmer Ext (31.6%)				
9	Number of local institutions participated in	6	0	2.35	1.09
10	Radio ownership (1 for those who owned 0 otherwise)	1	0	0.26	0.44
	- Number of people owning radio (118 out of 452)				
11	Area under Irrigation (Ha)	18	0	0.422	1.121
12	Agro-ecology(3 for lowland, 2 for mid highland and 1 for highland)	3	1	2.29	0.752
	- Highland (17.90%)				
	- Mid highland (35.20%)				
	- Lowland (46.90%)				
13	Indigenous early warning (IEWS)	1	0	0.43	0.49
	- %age of people having IEWS (56.20%)				
	- % age of people has no IEWS (43.80%)				
14	Formal Early warning (1 for those who have FEWS 0 otherwise)	1	0	0.45	0.49
	- %age of people having FEWS (54.9%)				
	- %age of people has no FEWS (45.1%)				
15	Number of non- farm activities	6	0	0.24	0.61
16	Number of Awareness raising/meeting participated on CC issues	5	0	2.08	1.56

Sources: computed from HH survey 2011/12

level of perception to climate change. Variables that positively and significantly influenced the perception of the farmers about the change in climate conditions over years include access to awareness raising meetings regarding climate change and natural environment issues, knowledge of indigenous early warning information, access to formal early warning information, frequency of contact with agricultural extension agents, educational level of household head and age of the household head. In this regard , increasing the exposure of a farmer to awareness meeting on climate change issues and natural disasters plays posetive role in terms of improving farmer’s perception of future changes . From this, it is apparent that investment on improvement of the ways in which early warning information dessiminates and imporvement in the education level of household head would yield a better result in terms of improving the understanding of the prevailing climate change.

On the other hand, the model output has shown that variables like distance from the market was negatively related to the perception of climate change though not found as such significant. This is due the fact that the more a farmer is distant from output market and input market, the less likely he or she can have more contacts for information sharing. Market places are usually the place where rural household exchange information regarding all matters of the agricultural activities as well as socio-economic issues. Market places in the study location are very few, where some of the farmers were required to travel more than half a day to reach market

Table 5. Heckman Result for the sample selection equation.

Independent Variables	Coefficient	St. error
Access to CC Awareness meeting	0.38***	0.227
Non-farm engagement	0.68	0.347
Access to formal EW information	1.017*	0.602
Area under irrigation	1.34**	0.683
Indigenous EW information	0.95**	0.423
Agro ecology: Lowland	1.427***	0.347
Midland	0.045	0.067
Highland	0.002	0.032
Ownership of Radio	0.17	0.569
Involvement in local institutions	0.32*	0.204
Frequency of Agricultural Extension Visit	0.248***	0.098
Farmer to farmer Extension	1.142	0.5669
Number relatives	0.111*	0.00689
Distance from market	-0.316*	0.2723
Household Size	0.178*	0.111
Educational level	0.255**	0.115
Gender of household head	1.58**	0.750
Age of household head	0.035**	0.0169
Access to Credit	0.90*	0.5523
Farm size	-0.037	0.0504
Area under perennial crops	0.32	0.5252
Livestock ownership	0.17	0.1572
Constant	-3.273	1.8241
Total Observation	418	
Wald Chi square	90.39%	

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

places. From the above Table 5, it is apparent that a unit increase in the distance of a farmers from a market will lead to an increase in probability of not perceiving by significant level. Similarly, the male headed households have better level of perception to climate change as compared to female headed households, this is may be because of the network of a family in accessing information which indicates a differential access of gender to climate change information issues. This result is in line with the argument that male-headed households are often considered to be more likely to get information about new technologies, climate and take risky businesses than female-headed households (Asefa and Berhanu, 2008).

Alike the expectation of the research, farmers living in the *Kolla* (lowland) have better level of perception about the climate change. Farmers living in *Woinadega* (midland) and *Dega* (highlands) perceived less change in climate than farmers in Kolla (low land). Thus the model ouput revealed that farmers living in the already hotter and mositure stress area has better level of climate change perception.

Adaptation to Climate Change Impact

Farmer's adaptation strategies to climate change impacts

Adaptations are adjustments or interventions, which take place in order to manage the losses or take advantage of the opportunities presented by a changing climate (IPCC 2001). Adaptation is the process of improving society's ability to cope with changes in climatic conditions across time scales, from short-term (e.g. seasonal to annual) to the long-term (e.g. decades to centuries). The IPCC (2001) defines adaptive capacity as the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. The goal of an adaptation measure should then be to increase the capacity of a system to survive external shock or change (Nhemachena et al., 2008).

Adaptation to changing climate conditions improves society's ability to cope with the changes across longer time scales against short term (e.g. decades to centuries). In a rural community where agricultural activity is the dominant means of living, adaptive capacity brings the ability of a farming system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. In community's life the ultimate goal of an adaptation measure is to increase the capacity of a farming system to survive external shocks or change. The assessment of farm-level adaptation strategies is important to provide information that can be used to formulate policies that enhance adaptation as a tool for managing a variety of risks associated with climate change in agriculture.

Micro-level analysis of adaptation focuses on tactical decisions farmers and local communities make in response to seasonal variations in climatic, economic and other factors. These tactical decisions are influenced by a number of socio-economic factors that include household characteristics, household resource endowments, access to information (seasonal and long-term climate changes and agricultural production) and availability of formal institutions (input and output markets) for smoothening consumption. Farm-level decision making occurs over a very short time period usually influenced by seasonal climatic variations, local agricultural cycle, and other socio-economic factors

In the study area, the dominant crops for subsistence and cash for the communities were *Teff*, Maize, Wheat, Barley, Sorghum, Millet, Wild Oats, Fababean and Pea, which comprises more than 97% of the total production and consumption. Other less dominant crops are beans, potatoes, cabbages, onions and carrots. However, crop yields in all areas was on a declining trend due to climate change, land degradation, pests and diseases, high cost of inputs, decreasing land sizes, etc. Regarding the cropping dominance observed over the course of the last 20 years, Sorghum, Millet, Wild Oats and Fababean become the dominant, while the others have generally decreasing in terms of land allocated for their production. That is a clear indication that farmers were taking up crops that were inherently resilient to moisture stress and mounting temperature. Experiences of effects of climate change and scarcity of resources have forced the communities to take up some adaptation strategies towards ensuring food security and environmental conservation. The biggest efforts have been towards tree planting, which the farmers did without knowing the positive impact the trees would have on carbon sequestration. Where as according to Neufeldt et al. (2009), carbon sequestered by trees and stored in aboveground biomass and soil contributes to reducing greenhouse gas concentrations in the atmosphere. The other adaptation strategies farmers in this area have taken was the development of small scale irrigation especially in the Yaya Gulele district. That was contributing a lot in terms of enabling the farmers to withstand the frequesnt rainfall faliure.

Moreover, theories and emperical researchers around the world have identified wide variety of adaptive actions that may be taken to lessen or overcome the adverse effects of climate change induced shocks on agriculture. At farm's level, adjustments may include the introduction of early maturing crop varieties or species, switching cropping sequences, sowing earlier, adjusting timing of field operations, conserving soil moisture through appropriate tillage methods, use of perennial crops and improving irrigation efficiency. Some options such as switching crop varieties may be inexpensive while others, such as introducing irrigation (especially high-efficiency, water-conserving technologies) involve major investments. Economic adjustments include shifts in agro-ecological production areas and adjustments of capital, labor, and land allocations. At community and country level, for example, trade adjustments should help to shift commodity production to regions where comparative advantage improves; in areas where comparative advantage declines, labor and capital may move out of agriculture into more productive livelihood options. Studies combining biophysical and economic impacts show that, in general, market adjustments can indeed moderate the impacts of reduced yields (Bradshaw et al., 2004; Kurukulasuriya et al., 2006a; Maddison, 2006; Nhemachena et al., 2007).

In areas like that of our study location, where the occurrence of drought and high variability of rain become common, major adaptive response were breeding of heat- and drought-resistant crop varieties by utilizing genetic resources that may be better adapted to new climatic and atmospheric conditions. Crop varieties with higher yields helps to keep irrigated production efficient under conditions of reduced water supplies or enhanced demands.

In response to these impact and long-term perceived changes, farm households in the study sites have undertaken a number of adaptation measures, including changing crop varieties, adopting soil and water conservation measures, tree planting, and changing planting and harvesting periods, use of irrigation, adoption of water harvesting techniques, planting perennial crops, diversified livelihood options and others. Such adaptation strategies were also identified by the works of Bradshaw et al. (2004); Kurukulasuriya and Mendelsohn (2006a); Maddison (2006); and Nhemachena and Hassan (2007). Table 6 below describes the different types of adaptive measures followed by farmers in response to perceived long term change in climate parameters; especially temperature and rainfall.

In general, 61.3% of the farm households have taken at least three of these adaptive measures. Majority of these adaptation measures were related to maintaining or improving agricultural yield. And these adaptive measures related to yield account for more than 90% of the measures followed by the farm households that actually undertook an adaptation measure to climate change impact. The other categories of adaptation measures were non–yield related and include desperate-

Table 6. Measures taken by farm households to adapt to climate change.

S/N	Adaptive Measure	Percentage of farmers
1	Use improved verity/early maturing	40.9
2	Use drought tolerant	35.8
3	Use Disease tolerant	31.4
4	Change cropping calendar	48.9
5	Change cropping locations (altitude)	38.9
6	Use irrigation	35.8
7	Increased use of fertilizer/ other tech.	61.5
8	Shift from crop to livestock or the vice versa	22.3
9	Use improved animal breeds	20.4
10	Diversify livelihood	35.2
11	Diversify income sources	32.3
12	Use soil and water conservation	56.9
13	Total livelihood change	24.8
14	Dietary change	48.0
15	Water harvesting	25.9
16	Planting trees around and within crops	26.5
17	Constructing flood control	37.6
18	Building wind breaks	38.9
19	others	9.3

Source: Computation from household survey

migration, engagement in daily labor works, and complete change of livelihood from agriculture to other sectors. On the other hand, about 2.9% have taken no adaptation measure and 38.7% have taken only one or two measures that may not ensure well adaptation to climate change. Moreover, this category of respondents has clearly indicated that they have failed to adapt to climate change impact. Majority of the respondents who took no adaptation measures indicated lack of knowledge, shortages of labor, shortage of land, and shortage of money as major reasons for not doing so. In fact, lack of knowledge was cited as the predominant reason by more than 60% of these households.

Determinants of farmer's adaptation to climate change impacts conditioned on perceived Change

In this analysis of the determinants of adaptation to climate change using heckman two stage model, variables that were found to have theoretical justification and emperical evidences were included in the model as the determinants of perception of climate change as shown in Table 5 above. In the second stage, which was the outcome equation, model for the analysis of adaptation to climate change, all relevant variables were included. In this model the measurement as to whether the farmers has adapted to the changing climate condition or not was modeled, by being conditioned on the first model.

For this analysis of adaptation to climate change in the North Shewa, a range of variable were included into the model. These variables include household charcterstics (sex of HH head, age of HH head, educational level of HH head, household size and marital status of HH head), social capital; which measure access to formal and informal institutions (formal extension, farmer-to-farmer extension, access to formal credit, number of institutions participated in, and relatives on the community), agro-ecology (lowland, mid highland amd highland), and other HH economic charcterstics (non-farm income, livestock ownership, farm size, number of plots, distance from input marker, access to improved technology, distance from output market and ownership of perennial crops) and farmers awarenss level of climate change issues.

The dependant Variable

The dependant variable for the outcome model was adaptation to climate change. This just involved asking farmers as to whether they have adapted or not in which the response was either yes or no, following the methods used by Deressa (2008), Maddison (2006), Nhemachena et al. (2007) and Woldeamlak, et al (2011). Some of these writers have used a Heckman prob in the regression to identify the determinants of adaptation, including perception to climate change as one of the independent variables. In those studies, the dependant variable was treated as binary. This, however, has a limitation in that a farmer that responds saying 'yes' to the question that asks, "have you adapted to the changing climatic condition?", might have not followed feasible adaptation strategies, even though it may asume it has adopted.

Therefore,the second alternative followed in this analysis was measuring the type and number of different adaptaion strategies followed by a typical farmer. Each of the strategies were measured and gave a farmer a value over a range of scale measurement. Thus adaptation was measured as a dependent variable by taking range of adaptaiton measures a farmer has undertaken. The major adaptation strategies followed by farmers in the study area are listed in Table 6 above. Consequently, Likert-type scale was used to measure adaptation level based on the level of farmers practice of each strategy. Then based on the number of adaptaiton strategy out of the 19 options, respondents number of adaptation option was taken and divided by the 19 options existing in the study area to generte the dependant variable; adaptation to climate change. In this regard, for instance a farmer that has adopted only one option will get a value of 0.0526 (which is obtained by dividing 1 to 19. On the other exterem, farmers that have adopted the 19 options got value 1 (which is obtained by dividing 19 to 19. And this validate the use of Heckman model for this analysis as the dependant variables have become continuous.

Model Outputs for Outcome Equation of Heckman model

The independent Variables

Perception to Climate change Impact

The analytical result of the data from individual households suggests that the knowledge about envisaged future changes (i.e. perception) in climatic conditions strongly govern household decisions about adaptation. Access to awareness about climatic conditions and information about future climate change enables farmers more likely to adjust their farming practices in response to climate change. Various studies conducted confirm that awareness of climate change is an important determinant of farm-level adaptation. The Mills ratio in the adaptation model shows the coefficient of sample selection equation as a whole; which is peceived future climate change. The coefficient of the peceived change (0.44) is significant at 10% probability level. This indicates that perceived change poses sample selectivity. Moreover, the likelihood function of the Heckman model was significant (Wald χ^2= 90.39, with $p < 0.0000$) showing strong explanatory power of the model. Therefore, perception to climate change is an important step to adapt to the change in climatic condition. For this to happen it is important to work on the determinants of percieption so as to foster high perception level and there by promote adaptation to climate change.

Credit

Access to credit, was an important factor in climate change adaptation. One of the most improtant factors among the rural households to foster their agricultural production and sustaining livelihood under extreme climate situation was the availability of finance to purchase the necessary inputs and cover cash needs. This implies availability of credit services and farmer's access to credit cash constraints allows farmers to purchase necessary inputs such as fertilizer, improved crop varieties and irrigation facilities. Researches on adoption of agricultural technologies indicate that there is a positive relationship between the level of adoption and the availability of credit (Yirga 2007). Thus, this study also hypothesized that access to credit will have significant positive impact on adaptation to climate change. In the adaptation model, the coefficient of access to credit was 0.239, which was significant at all conventional levels.

Access to Extension, no of institutions, Access to indigenous EWS and participation in local institutions

The history of agricultural extension in Ethiopia goes back to Imperial regime of Haile Sillasie (Tesfaye 2003). The availability of appropriate extension services on crops, livestock and climate change issues play a vital role in building community's adaptation to changes. This is because farmer's decision about their action will be an informed one. Various studies in developing countries including Ethiopia reported a strong positive relationship between access to information and the adoption behaviors of farmers (Yirga 2007). Moreover, Maddison (2006) and Nhemachena and Hassan (2007) showed that access to information through extension increase the chance of adapting to climate change. Therefore, based on these literature it was hypothesized that household's access to formal and informal services like extension services, number of local institutions participated in and number of relatives in a community increase the chance of adapting to climate change. From Table 7, the model output clearly supported this argument that households having good extension services, involvements in many local institutions, access to indigenous EWS and larger-number of relative in a community has exhibited significance at 10%, 5%, 5% and 10% probability levels, respectively.

Table 7. Model output for the adaptation model conditioned on the perception to climate change.

	Regression	
Independent variables	**Coefficient**	**Standard Error**
Access to CC awareness meeting	0.0616***	0225453
Non-farm engagement	0.1626***	.0507622
Indigenous EWS	0.181***	.0664995
Agro-ecology: Lowland	0.089*	.0543051
Midland	0.0034	0.0067
Highland	0.0047	0.00678
Number of institution engaged in	0.087***	.0295892
Access to agricultural extension	0.032*	.017844
Number of relatives in a community	0.00178*	.0004061
Distance from market	-0.241**	.0481282
Educational level of HH head	0.691**	0160341
Marital status	0.094*	0547962
Access to credit	0.239***	.065663
Farm size	0.054**	.0056506
Area under perennial crops	0.101**	.0520298
Livestock ownership	0.0831**	.0180733
Constant	1.709***	.2532739
Mills	0.44*	0.070
Total observation	418	
Censored	26	
Uncensored	392	
Wald Chi2 (22)	90.39*	0.000

***, **, * = significant at 1%, 5% and 10% probability levels respectivel

Market Access

Having market outlet has significant impact in terms of enabling farmers to immediately take their perishable commodities like vegetables, fruits, livestock products to market to survive from lose that may come due to change in weather conditions. Moreover, access to market or being 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). In this connection, this study also hypothesized that there was positive relationship between access to output/input markets and adaptation. According to the data collected from household survey some households were half a days away from market, while others live proximity to a market. Correlation coefficient indicates that there is a strong correlation between distance from market and adaptation to climate change impact. From the above Table 7 as well, the model output for market access in North Shewa was found to be significant determinant of adaptation to climate change at 5% probability level.

Agro-ecology

Households residing in locations where the experience of very low rainfall than average in the *Belg* (fall) season were also more likely to adopt adaptation strategies compared to households in areas receiving relatively good average rainfall. Whereas, households getting rainfall above the average during the *Mehere* (summer) season were not that much likely to adapt to climate change. Significant differences were also observed across the various agro-ecological zones when it came to the likelihood that households would undertake measures to adapt to the different climate change induced shocks. In this connection, households' living in lowland took more than 10 adaptation measures, while people living in mid highland and highland took less than 5 and 3 adaptation measures on average, respectively. For instance households in the lowlands (*Kolla*) were more likely to adapt to very low rainfall, disease outbreaks, damage to winds, and low humidity as compared to households living in the other agro-ecological zones.

HH Characteristics

Similarly, significant differences in responses were also observed based on household size, marital status, age of the household head, and literacy levels of household heads. In general, larger households, those whose heads were older and more literate with relatively better access to technology were more likely to adapt to the changes, indicating the importance of available labor, sufficient experience and access to information as factor that boosts adaptive capacities. In this connection, the education level of household and marital status of household head were found to be significant determinants of adaptation to climate change at 10% and 1% probability levels, respectively.

Non Farm income, Livestock ownership, perennial crops and farm size

Participation in different types of non-farm income, livestock ownership, area under perennial crops and farm size, represent wealth. It is regularly hypothesized that the adoption of agricultural technologies requires sufficient financial well-being that may come from non-farm operations (Knowler and Bradshaw, 2007). Other studies, which investigate the impact of income on adoption, revealed a positive correlation (Franzel, 1999). Higher income farmers may be less risk averse, have more access to information, have a lower discount rate and longer term planning horizon (CIMMYT, 1993). Livestock plays a very important role by serving as a store of value, source of traction (specially oxen) and provision of manure required for soil fertility maintenance (Yirga, 2007). Similarly, the ownership of perennial crops that yearly yields output provides the capacity to withstand natural shocks that damage production of annual crops and interrupts some of the livelihood operations. Thus the number and types of livestock, and areas under perennial crop owned were hypothesized to have positive impact on adaptation to climate change. The result for the study area shows that farmers with diversified non-farm income, large number of livestock and big size of land under perennial crops were found to have higher level adaptation to climate change induced shocks as compared to farmers who are less endowed with such wealth at 1%, 5% and 5% probability levels, respectively.

Farm size is also associated with grater wealth and it is hypothesized to increase adaptation to climate change. Whereas some literature from studies on adoption of agricultural technologies indicates that farm size has both negative and positive effect on the adoption showing that the effect of farm size on technology adoption is inconclusive (Bradshaw et al., 2004). However, the result of this study revealed that households with relatively big farm size were more likely to take up more adaptation strategies when compared to farmers with small farm size.

Impact of perception on adaptation

Agricultural change does not involve a simple linear relationship between changes in a farmer's decision making environment and farm-level change. One important issue in agricultural adaptation to climate change is the level to which farmers update their expectations of the climate in response to unusual weather patterns. A farmer may perceive several hot summers but rationally attribute them to random variation in a stationary climate. Another important issue related to adaptation in agriculture pointed out by Bryant (2000) is how perceptions of climate change are translated into agricultural decisions. If the perception level grows gradually about the change in climate, Maddison (2006) argues that they will also learn gradually about the best techniques and adaptation options available. According to him, farmers learn about the best adaptation options through three ways: (1) learning by doing, (2) learning by copying, and (3) learning from instruction.

In climate change adaptation research at farmer's level, the basic focus is how much more important is climate change perception for adaptation and how far is perceived change been able to inform adaptation. This will enable to make deliberate programming to improve the awareness level of farmers on the changes. Perception of farmers about the future change in climate variables has significant impact on adaptation to the change. According to the arguments and evidences portrayed by researchers like Maddison (2006), adaptation to climate change is a two-step process which involves perceiving that climate is changing in the first step and then responding to changes through adaptation in the second step. Thus, perception has an impact on adaptation level. Even though farmers are endowed with good resources bases and other factor for adaptation, the more perceived farmers adapt highly than those farmers who have very low level of perception. Even though the farmer owns small plot of land, less diversified livelihood options, low non-farm income, etc, the condition of being highly aware of climate change and its impact enables high adaptation. The table below describes the different adaptation strategies adopted at different levels of perception. It analyses as to whether farmers with higher level of perception will have higher level of adaptation confirming the result in table 7, with significant Mills ratio coefficient for factors of perception.

From Table 8, it is apparent that farmers who have high perception level, as measured by the number of climate variables the farmer has perceived over the couple of decades have by far adapted to the changes by

Table 8. Farmer's level of perception and corresponding adaptation strategies adopted.

Lists of climate change variables	Level of Perception	Average number of adaptation strategies adopted
Rainfall (amount and Distribution), Temperature level, Humidity, Soil moisture, Wind direction, Wind Speed, and Cropping calendar.	Perceived change in only one of the climate change variables	2
	Perceived change in two of the climate change variables	3.5
	Perceived change in three of the climate change variables	8.5
	Perceived change in four of the climate change variables	9.1
	Perceived change in five of the climate change variables	11.9

Source: Computed from HH survey

taking more adaptation options. Therefore, apart from econometric result, from statistical point of view, high level of perception is correlated with higher level of adaptation to climate change impacts.

Households Coping Strategies to Climate Change Induced Natural Shocks

Indigenous people in the world have used variety of strategies to cope up with climate change induced shocks. These coping strategies include: diversified resource base (to minimize the risk due to harvest failure, they grow many different crops and varieties, and they also hunt, fish, and gather wild food plants); change in crop varieties and species; change in the timing of activities (crop harvests, wild plant gathering, hunting and fishing); change of techniques; change of location; changes in resources and/or life style (resorting to wild foods in the case of emergency situations such as droughts and floods); exchange (obtaining food and other necessities from external sources through exchange, reciprocity, barter, or markets in times of crises); and resource management (enhancing scarce and climate-sensitive resources management) (for details see Salick and Anja, 2007:15-17). The knowledge and experiences of peasant farmers in Ethiopia support these findings (Workineh, 2007).

As shown in various literatures, Ethiopian peasant farmers, through continuous experiments on their environment, have managed to learn how to control weeds and insects, select crop varieties, classify vegetation types, and cope with climatic and environmental changes. They have developed various strategies to cope with climate changes induced disasters. They conserve water resources and avoid unnecessary danger and crisis during dry seasons. They use drought-resistant crops to address problems related to climate variability and drought in particular (Kelbessa, 2001).

Coping strategies is the mechanisms used by individuals or nation as a whole to cope up with sudden or pre perceived events. According to Berkes and Jolly (2001) as quoted by Abate (2009), in the context of climate change, coping is temporal adaptation and is the actual response to crises on livelihood system in the face of unwelcome situation, and are considered as short term responses. Coping mechanisms may develop into adaptive strategies through times.

The people in the study are use different means to know the future and tackle future events. These peoples interpret climate change in various ways. Their interpretation depends on personal observations, experiences and local cultural framework. While scientific explanations of climate changes have mainly concentrated on anthropogenic, greenhouse gas emissions, local interpretations of observed climate changes are often much more varied and encompassing. Some people consider adverse weather conditions as punishments for human wrongdoings.

With such level of their understanding, farmers in the study location have followed different copying strategies when climate change induced shocks hit their lives and livelihood. From community's perspective, the diversity and indepthness of the different coping mechanisms have helped them even to go through some of the hard times in their lives. Some of the coping strategies have eroded the future hope of the farmers, while others have helped them to easily bear the consequences of environmental shocks. Table 9 below describes some of the different coping mechanisms and percentage of farmers who took that coping strategy in the past.

From the table, it is apparent that farmers pursue different coping strategies in study area. The major coping strategies were reduced frequency of meal, decreased quantity of meal, and decreased diversity of meal as responded by 69.7%, 69%, and 51%, respectively. These strategies have a negative repercussion on the health, productivity of individuals and psychosocial development of children in a family. From

Tabel 9. Coping strategies followed by farmers in the aftermath of climate change induced shocks.

Coping Strategies	%age of respondents
Reduced frequency of meal	69.7
Decreased quantity of meal	69.0
Decreased diversity of meal	51.3
Borrowed grains	47.3
Sought support from NGOs	45.8
Sought support from government	45.4
Borrowed cash	41.4
Sought support from friends/ relatives	38.5
Sales of livestock/oxen	34.1
Sought additional labor work	33.2
Sales of farm land	33.0
Distressed sale farm equipment	27.9
Distressed sale of household assets	27.9
Distressed migration of HH members	27.7
Engaged in the extraction and sale of natural resources	25.2
Sales of perennial crops	17.9
Others	6.9

Source: Computed from household survey

the analysis, it can be concluded that significant number of households took up coping mechanisms that can negatively affect their future livelihood and immediate rehabilitation from the shock. These includes but not limited to sale of farm land, sale of perennial crops, distress sale of farm equipments, sales of household assets and distress migration as practiced by 33%, 17.9%, 27.9%, 27.9% and 27.7% respectively. However, under normal circumistances, coping mechanisms like seeking additional labour work, borrowing grain, borrowing money and seeking support (from friends, relatives, government and non-government) can be seen as positive coping mechanisms.

In gernal, households do not follow a single coping strategy during those hard times. At a time a farm households usually take different strategies to maximize their positive survival. According to the data collected from the households' survey it was only 2.7% of the households that followed only single coping mechanism where as about 45%, 41%, 9.9% and 2% have followed 2 to 5, 6 to 10, 11 to 15 and more than 15 coping mechanisms, respectively.

CONCLUSION

The farm households in North Shewa have exhibited a higher level of perception to climate change induced disasters/shocks. According to the findings of the study, large number of farmers has good perception level about the changing temperature, rainfall, soil moisture, wind moisture, wind direction and others. The high level of perception was a result of access to awareness raising meetings, access to indigenous early warning information, farmer's location in terms of agro-ecology, access to frequent agricultural extension services, closeness to market, educational level, and age of household heads. The perception of farmers about climate change has significantly contributed to the adaptation to climate change. The analytical result from adaptation to climate change conditioned on perception have clearly shown that farmers who have perceived climate change impacts have adapted to the changes as compared to the households who exhibited lower level of perception. Therefore, it is worth concluding that perception plays significant role to adaptation and if purposed to achieve a higher level of adaption to climate change in the study area, one should invest considerable effort in raising the perception level of farmers by addressing the identified determinants of perception.

On the other hand, the study has identified that farmers follow different coping mechanisms to survive in the aftermath of a climate change induced shocks. Some of the coping mechanisms currently exercised in the study area compromise the future development and immediate rehabilitation of households. Thus, carefully targeted programming should be made to enable farmers take those positive coping mechanisms and exercise those strategies that can boost their adaptation to the changing climate condition in the long run.

Based on the analysis of adaptation to climate change, factors that dictate adaptation to climate change and perception of farmers to climate change in the North Shewa of Ethiopia, different policy options could be suggested. These policy options include awareness creation on climate change and adaptation methods through local awareness creation campaign, mainstreaming climate change issues into other trainings and conducting awareness meetings. Facilitating the availability of credit through encouraging micro financing institutions to widen their coverage of credit delivery to smallholder farmers and loosening some of the requirement to give loans from the sides of lenders is another important area to consider. Investment on non-farm engagement should be done by government as well as development actors on the ground as it reduces the pressure on natural environment and improve the capacity of farmer's to access more level of income and then be able to afford some of the adaptation options that are somehow expensive.

On the other hand, provision of advices to farmers so that they can improve good mix of livestock holding would help them diversify their livestock as adaptation mechanism. Government and local level development actors should encourage adult education, as majority of respondents were limited to adapt to climate change because of illiteracy in the adoption of improved technologies. Indigenous early warning information should be disseminated through meetings, farmer to farmer extension, extension agents and village level social meetings. Farmers' should be encouraged to diversify crops to perennial trees, which will enable them to have produces during climate change induced shocks. This can be done through the distribution of fruit and other seedlings by government offices as well as NGOs working in the area. Finally, it is important to improve frequencies of farmer's contact with extension agents by the local agricultural offices at districts level.

REFERENCES

Abate Fayisa (2009). Climate change impact on livelihood, vulnerability and coping mechanisms: A Case Study of West-Arsi Zone, Ethiopia.

Adger WN (2000). Social and ecological resilience: are they related? *Progress in human geography,* 24: 347-64.

Akililu Amsalu (2009). Assessments of Climate change induced hazards, impacts and responses in the southern lowlands of Ethiopia. Addis Ababa.

Assefa Admase, Berhanu Adenew (2008). Stakeholders' Perception of Climate change and Adaptation Strategies in Ethiopia. Research Report. Addis Ababa, Ethiopia.

Belliveau S, Smit B, Reid S, Ramsey D, Tarleton M, Sawyer B (2006). *Farm-level adaptation multiple risks: Climate change and other concerns.* Occasional paper No. 27. Canada: University of Guelph.

Berkes F, Jolly D (2001). Adapting to climate change: social-ecological resilience in a Canadian western Arctic community. Conservation Ecology, 5(2), 18.

Bradshaw B, Dolan H, Smit B (2004). Farm-Level Adaptation to Climatic Variability and Change: Crop Diversification in the Canadian Prairies. *Climatic Change* 67: 119–141.

Bradshaw BH Dolan, Smit B (2004). Farm-Level Adaptation to Climatic Variability and Change: Crop Diversification in the Canadian Prairies. *Climatic Change* 67: 119–141.

Brklacich M, McNabb D, Bryant C, Dumanski I (1997). Adaptability of agriculture systems to global climate change: A Renfrew County, Ontario, Canada pilot study. In *Agricultural restructuring and sustainability: Geographical perspective,* eds. B. Iibery, Q. Chiotti, and T. Richard. Wallingford: CAB International.

Bryant A (2000). Social research methods, Oxford New York.

CIMMYT (1993). Cereals production in sub Saharan Africa. New York

CSA (Central Statistical Authority) (2007). Population census. Addis Ababa, Ethiopia.

Deressa Temesgen, Hassan RM, Ringler C (2008). Measuring ethiopian farmers' vulnerability to climate change across regional states. IFPRI discussion paper No. 806. http://www.ifpri.org/pubs/dp/ifpridp00806.asp, Washington, DC.

Franzel S (1999). Socioeconomic factors affecting the adoption potential of improved tree fallows in Africa. *Agro forestry Systems*, 47(1-3): 305-321.

IPCC (2001). Climate change 2001: Impact Adaptation and vulnerability. Cambridge University press, Cambridge.

IPCC (2007a). Summary for policymakers in climate change impacts, adaptation and vulnerability. Contribution of working group ii to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press. Cambridge, UK. 7-22. Page 13.

IPCC (2007b). Climate change. The physical science basis, contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change. Cambridge, UK and New York. Cambridge University Press.

Isham J (2002). The Effect of Social on Fertilizer Adoption: Evidence from Rural Tanzania. *J. Afri. Econ. 11*:39-60.

Justice Christopher O (2005) Climate Change in sub-Saharan Africa: Assumptions,Realities and Future Investments, in Low, Pak Sum. (ed.). Climate Change andAfrica. Cambridge: Cambridge University Press, pp. 172-181.

Kelbessa Workineh (2001). Traditional Oromo Attitudes towards the Environment: AnArgument for Environmentally Sound Development. OSSREA Social Science Research Report Series, No. 19. Addis Ababa: Commercial Printing Enterprise. (Available online at http://www.ossrea.net/ssrr/workneh/toc.htm).

Ketema Tilahun (1999). Test of Homogenity, Frequency Analysis of Rainfall Data and Estimate of Drought Probability in Dire Dawa, Estern Ethiopia. *Ethiop. J. Nat. Res., 1: 125-136*

Knowler D, Bradshaw B (2007). Farmers' adoption of conservation agriculture: A review and synthesis of recent research. Food policy, 32(1): 25-48.

Kurukulasuriya P, Mendelsohn R (2006). *A Ricardian analysis of the impact of climate change on African crop land.* CEEPA Discussion Paper No. 8. Centre for Environmental Economics and Policy in Africa. Pretoria, South Africa: University of Pretoria.

Likert Rensis (1932). A Technique for the Measurement of Attitudes. *Archives of Psychology* 140: 1–55.

Maddison D (2006). *The perception of 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.

Mahmud Yesuf, Salvatore Di Falco, Temesgen Deressa (2008). The impact of climate change and adaptation on food production in low-income countries. Evidance from the Nile Basin, Ethiopia. IFPRI Discussion paper 00828. Washington DC, USA.

Markos Ezra (1997). Demographic Response to Ecological Degradiation and Food Insecurity: Drought prone areas in Northern Ethiopia. Amesterdam: PDOD Publication

McCarthy J, Canziani OF, Leary NA, Dokken DJ, White C eds (2001). Climate change 2001. Impacts, adaptation, and vulnerability. Contribution of working group II to the third assessment report of the intergovernmental panel on climate change. Cambridge: Cambridge University Press.

Mendelsohn Robert, Wendy Morrison, Michael Schlesinger, Natalia Andronova (2000). Country-specific market impacts of climate change. *Climatic Change.* 45(3-4): 553-569.

Mengistu D (2011). Farmers' perception and knowledge of climate change and their coping strategies to the related hazards: Case study from Adiha, central Tigray, J. Agric. Sci., Vol.2, No.2, 138-145 (2011).

Mezw-Hausken E (2004). Contrasting climate variability and meteorological droughts with perceived drought and climate change in Northern Ethiopia. *Climate research*, 27: 19-31.

Mulat Demeke (2004). Hydrological Variability in Ethiopia: Its Impact and some strategic Considerations. Background Paper for Ethiopia Water Resources Assistance strategy of the World Bank. Unpublished Report, Addis Ababa.

Neufeldt H, Wilkes A, Zomer RJ, Xu J, Nang'ole E, Munster C, Place F (2009). Trees on farms: Tacling the multiple challenges of mitigation, adaptation and food security. World Agro-forestry Centre Policy Brief 07. World Agro-forestry Centre, Nairobi, Kenya.

Nhemachena C, Hassan R (2007). *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 Methrological Service Agency) (2012). Statistical report of rainfall and temprature for north Shewa Zone of Oromia Regional state, Addis Ababa, Ethiopia.

Pearce D, Cline W, Achanta A, Fankhauser S, Pachauri R, Tol R, Vellinga P (1996). The social cost of climate change. Greenhouse damage and the benefit of control. In climate change 1995. Economic and social dimension of climate change. Ed. J. Bruce, H. Lee and E. Haites. Cambridge. Cambridge University Press.

Salick Jan, Byg Anja (2007). Indigenous Peoples and Climate Change. (Available online at http://tyndall.webapp.uea.ac.uk/publications/Indigenouspeoples.pdf).

Smith JB (1996). Using a decision matrix to assess climate change adaptation. In *Adapting to climate change: Aninternational perspective,* ed. J.B. Smith, N. Bhatti, G. Menzhulin, R. Benioff, M.I. Budyko, M. Campos,B. Jallow, and F. Rijsberman. New York: Springer.

Smith JB, Lenhart S (1996). Climate change adaptation policy options. In *Vulnerability and adaptation of African ecosystems to global climate change*, CR special, 6(2), book version.

StataCorp (2003). Stata base reference mannual. Volume 4, g-m. Release 8. College station. Tx: stata corporation

Tesfaye Besha (2003). Understanding farmers.Explaining soil and water cnservation in Konso, Wolaita and Wello, Ethiopia. Wageningen University research center, the netherlands.

Woldeamlak Bewket, Dawit Alemu (2011). Farmers' Perception of Climat change and Its Agricultural Impact in the Abay and Baro-Akobo River Basin. *Ethiop. J. Dev. Res. Vol 33, No 1*, Addis Ababa, Ethiopia.

Workineh Kalbessa (2007). Climate change impacts and indigenous coping strategies in Africa. Greifswald University, UK.

WVI (2011). Strategic planning document for food security and climate change learning centre for east Africa. Arusha, Tanzania.

Yirga CT (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.