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Farmers Perception on Climate Change and Determinants of Adaptation Strategies in Benishangul-Gumuz Regional State of Ethiopia

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ABSTRACT

Adaptation to climate change involves changes in agricultural technologies in particular and management practices in general to reduce its risk and effects. To minimize the losses due to climate change factors, farmers have employed different climate change adaptation strategies. Consequently, this study examines farmer adaptation strategies to climate change in Benishangul-Gumuz Regional State of Ethiopia based on a cross-section data of three representative zones of Assosa, Kamashi zones and Mao-komo special district. The study describes the perceptions of smallholder farmers to changes in climate change indicators and adaptation measures at the farm household level using multivariate discrete choice model to identify the determinants of adaptation strategies. The econometric model has showed that households demographic factors, resources endowments (land, labor, livestock), institutional factors (access to extension services, cooperative membership and access to credit) are some of the important determinants of farm-level adaptation. The policy implication from our finding is that improving access to credit, production factors (like land, labor) enhancing the bargaining power of smallholder farmers can significantly increase farm-level adaptation to climate change. Moreover, adopting different improved crop varieties have showed better yield gains than non-adopters. Thus, policies and strategies should focus at research and development on appropriate technologies that help smallholder farmers' adaptation capacity to climate changes hereby varietal development, appropriate agronomic recommendations, pre-extension demonstration and popularization of improved cultivars and promoting appropriate farm-level adaptation measures such as use of irrigation technologies.

Keywords: Climate change; adaptation; micro level

1 Introduction

Climate change is currently threatening the livelihoods of millions of people who are already poor and vulnerable, by altering the natural and physical assets they rely on, particularly for agricultural production. Climate change is expected to present heightened and new combinations of risks and potentially grave consequences on daily life and economic activities.

Climate change is one of the most serious environmental threats facing mankind worldwide. This is particularly true in Africa where direct dependence on the natural environment for livelihood support combined with a lack of infrastructure and high levels of poverty to create vulnerability in the face of all types of environmental change. It affects agriculture in several ways, including its direct impact on food attributed by the natural climate cycle and human activities that leads to adverse effect to agricultural productivity in Africa and due to their low level of coping capabilities (Ziervogel et al. 2006, Nwafor 2007; Jagtap 2007).

Adaptation to new climatic conditions is, hence, a necessary strategy for those living in the affected parts of the world. Adaptation comprises measures of prevention as well as measures of adopting a change in a traditional way of life.

Climate change adaptation aims to mitigate and develop appropriate coping measures to address the negative impacts of climate change on agriculture both at the short run and long-run. Most agricultural systems have a measure of in-built adaptation capacity ("autonomous adaptation") but the current rapid rate of climate change will impose new and potentially overwhelming pressures on existing adaptation capacity. This is particularly true given that the secondary changes induced by climate change are expected to undermine the ability of people and ecosystems to cope with, and recover from, extreme climate events and other natural hazards. Accordingly there is a growing focus on the need for "anticipatory adaptation" (UNDP, 2007), that is the proactive rather than the reactive management of climate change risk. Anticipatory adaptation relies on the best available information concerning the nature of future climate risks.

In agriculture, among the most frequently advocated strategies for climate adaptation is technology research and development (Houghton, Jenkins, and Ephrams, 1990; Rosenberg, 1992). Innovations in agriculture have always been important and will be even more vital in the context of climate change. The development and effective diffusion of new agricultural practices and technologies will largely shape how and how well farmers mitigate and adapt to climate change. This adaptation and mitigation potential is nowhere more pronounced than in developing countries where agricultural productivity remains low; poverty, vulnerability and food insecurity remain high; and the direct effects of climate change are expected to be especially harsh.

Farmers have adopted different mechanisms in order to adapt climate change like adoption new improved technologies, skills and knowledge. Hence, research and development has been working on generating, developing and dissemination of appropriate technologies that enable the farming communities to improve their livelihoods. The profound effects of research and technological development on crop and animal productivity in both the developed and developing world are unquestionable and well documented elsewhere (USDA, 1990; Reilly and Fuglie, 1998).

The indicators of impact of climate change in Ethiopia showed that over the last decades, the temperature increased by about 0.2°C per decade (Brohan, et al 2006). The same report indicates that the increase in minimum temperatures is more pronounced with roughly 0.4°C per decade. The seasonal rainfall distribution in Ethiopia is also driven mainly by the migration of the Inter-Tropical Convergence Zone (http://country-profiles.geog.ox.ac.uk). In Ethiopia, the onset and duration of the rainfall seasons vary considerably inter-annually, causing frequent drought. Climate change can have severe impact on societies which depend for their existence on traditional agricultural methods (Hassan and Nhemachena, 2008).

The consequences of harvest failure due to extreme weather events is the most important cause of risk related hardship of Ethiopian rural households, with adverse effects on farm household consumption and welfare (Dercon 2004, 2005). However, the National Research System of Ethiopia in collaboration with stakeholders in agricultural research and development has been contributing to the development of agriculture in the country through generating, development, transfer and facilitating the adoption of agricultural technologies. Thus, a number of crop, livestock and natural resource related technologies have been disseminated among smallholder farmers who face and confront the vagaries of the ever-changing climate. New technologies and practices that are resistant to drought are developed to reduce the risk of famine and increase returns.

However, very little is known about the roles of these technologies in fighting against climate change and the associated impact on farmers' choice of adaptation strategies. The climate change technology needs assessment study could provide technological options in the context of climate change (NMA, 2007). Climate change adaptation strategies have been studied at Assosa district (Sani et al., 2016). However, this study has limited scope to only Assosa district and the sample size was also small. Hence, climate change adaptation strategies and the causes and effects of climate change in Assosa Zone, Kamashi, and Mao-Komo special district was not yet investigated. There is a need to target appropriate policy recommendations on technology transfer to facilitate climate change adaptation and mitigation as effective ways of promoting agricultural development. Also there is a need for effective policy responses to encourage the development, transfer and diffusion of appropriate agricultural technologies to promote agricultural development and climate change adaptation and mitigation in the face of changing climatic scenario.

Therefore, the perception and determinants of climate change adaptation strategies was identified using cross sectional data collected and analyzed using multivariate probit model (MVP) in Benishangul-Gumuz region of Ethiopia. The results revealed that different adaptation strategies have been adopted by smallholder farmers to minimize risk and shocks of climate variability. Based on the results we have drawn policy recommendation that help decision making processes regarding climate change strategies on research results based on empirical evidences.

2 Material and Methods

2.1 Dataset and Variables

2.1.1 Sampling and data collection

The research was conducted at crop livestock mixed farming system in Benishangul-Gumuz Region of Ethiopia. The survey was conducted at Mao-komo-Special district, Assosa and Kamashi Zones of Benishangul-Gumuz region. The study areas were classified based agro-ecology. A total of 205 household heads were randomly identified from the different climatic zones based on proportion to size criteria (See Annex I). However, one household was removed from analysis due to insufficient data collected from the household and 204 sampled households were considered for analysis. About 81 % and 19 % of the sampled households farming type was crop-livestock mixed farming and crop only respectively.

Sampled household heads were interviewed using a well-defined interview schedule. The type of data collected pertains household characteristics (demography, asset endowment including experience, education and physical/natural resources), livelihood strategies (income generation and adaptation mechanisms), technological options, farming/institutional environment (access to support institutions: finance, input, market, technical backstopping,), the biological environment (drought, pests),

2.2 Data Analysis and Model Specification

2.2.1 Determinants of participation and Interaction: Multivariate probit model

Data were analyzed using descriptive, exploratory and econometric techniques. The descriptive approach includes percentages, mean, median standard deviation and appropriate statistical tests. It involves tabular analyses and testing the distributional importance of agricultural technologies and climate change adaptation mechanisms.

The econometric techniques emanate from the nature of the data. Hence, univariate probit model can be employed to analyze the factors determing the different adaptation strategies (Maddala 1983; Long 1997; Long & Freese 2005; Cameron & Trivedi 2009; Greene 2012):

$$\gamma *_{im} = \beta_m{}' X_{im}{}^{*} + \varepsilon_{im,} m = 1, \dots, M \tag{1}$$

$$\gamma *_{im} = 1 \text{ if } \gamma *_{im} > 0 \ and\ 0\ otherwise; \tag{2}$$

Where $\gamma *_{im}$ is the binary latent variable for the different climate change adaptation strategies in our case the eight strategies (observed if $\gamma *_{i}$ >0, 0 otherwise); and X is a vector household specific and other socio-economic factors determining climate adaptation strategies. However, the above univariate probit and multinomial probit estimations of climate change adaptations strategy measures would be misleading for the expected problem of simultaneity. The adoption of one type of agricultural technology would be dependent on the adoption of the other, since household adoption decisions are interdependent, suggesting the need to estimate them simultaneously. To account for this problem, a seemingly unrelated multivariate probit simulation model was employed (Long 1997; Chib & Greenberg 1998; Cappellari & Jenkins 2003, Degie et al., 2013):

$$Cropdiv^*_i = X_1{}'\beta_1{}^* + \varepsilon_{1i,}$$
$$Irr\ ^*_i = X_2{}'\beta_2{}^* + \varepsilon_{2i,}$$
$$DiffVar\ ^*_i = X_3{}'\beta_3{}^* + \varepsilon_{1i,}$$
$$LandChange^*_i = X_4{}'\beta_4{}^* + \varepsilon_{4i,}$$
$$CapitallabChange\ ^*_i = X_5{}'\beta_5{}^* + \varepsilon_{5i,}$$
$$ChemicalSpraying\ ^*_i = X_6{}'\beta_6{}^* + \varepsilon_{6i,}$$
$$Ridge\ ^*_i = X_7{}'\beta_7{}^* + \varepsilon_{7i,}$$
$$DiffPlDat\ ^*_i = X_8{}'\beta_8{}^* + \varepsilon_{8i,} \quad (3)$$

where

$$\begin{bmatrix}\varepsilon_{1i}\\ \varepsilon_{2i}\\ \varepsilon_{3i}\\ \varepsilon_{4i}\\ \varepsilon_{5i}\\ \varepsilon_{6i}\\ \varepsilon_{7i}\\ \varepsilon_{8i}\end{bmatrix} = \sim \boldsymbol{N}\begin{bmatrix}0\\0\\0\\0\\0\\0\\0\\0\end{bmatrix}\begin{pmatrix} 1 & \rho_{12} & \rho_{13} & \rho_{14} & \rho_{15} & \rho_{16} & \rho_{17} & \rho_{18}\\ \rho_{21} & 1 & \rho_{23} & \rho_{24} & \rho_{25} & \rho_{26} & \rho_{27} & \rho_{28}\\ \rho_{31} & \rho_{32} & 1 & \rho_{34} & \rho_{35} & \rho_{36} & \rho_{37} & \rho_{38}\\ \rho_{41} & \rho_{42} & \rho_{43} & 1 & \rho_{45} & \rho_{46} & \rho_{47} & \rho_{48}\\ \rho_{51} & \rho_{52} & \rho_{53} & \rho_{54} & 1 & \rho_{56} & \rho_{57} & \rho_{58}\\ \rho_{61} & \rho_{62} & \rho_{63} & \rho_{64} & \rho_{65} & 1 & \rho_{67} & \rho_{68}\\ \rho_{71} & \rho_{72} & \rho_{73} & \rho_{74} & \rho_{75} & \rho_{76} & 1 & \rho_{78}\\ \rho_{81} & \rho_{82} & \rho_{83} & \rho_{84} & \rho_{85} & \rho_{86} & \rho_{87} & 1 \end{pmatrix} \quad (4)$$

$$E(\varepsilon|X) = 0$$
$$Var(\varepsilon|X) = 1$$
$$Cov(\varepsilon|X) = \rho \quad (5)$$

Where

$Cropdiv^*_i$, $Irr\ ^*_i$,, $DiffVar\ ^*_i$,$LandChange^*_i$,$CapitallabChange\ ^*_i$, $ChemicalSpraying\ ^*_i$, $Ridge\ ^*_i$ and $DiffPlDat\ ^*_i$

are households' climate change adaptation strategies like crop diversification, use of irrigation, adoption of different crop improved varieties, land change, capital and labor change, use of chemical spraying, using soil and water conservation techniques like ridging and changing planting date based on the offsetting of the rainfall respectively. X_1 *to* X_8 are vectors of independent variables determining the respective climate change adaptation strategies; $\beta's$ are vectors of simulated maximum likelihood (SML) parameters to be estimated; $\varepsilon_{1i,}$ to $\varepsilon_{8i,}$ are correlated disturbances in a seemingly unrelated multivariate probit model; and ρ's are tetra choric correlations between endogenous variables.

In our case there are 58 joint probabilities corresponding to the eight possible combinations of successes (with value of 1) and failures (with value of 0). For instance, if we take the probability that every outcome is a success, the probabilities that the likelihood function of the climate change adaptation strategies simulation are explained as

$$\Pr(Cropdiv\ i = 1,\ Irr\ i = 1;\ DiffVari = 1;$$
$$LandChange^*_i = 1; CapitallabChange\ ^*_i = 1;$$
$$ChemicalSprayingi = 1, Ridgei\ = 1, DiffPlDati = 1$$
$$= \Phi_m(X_1\ \beta_1{}', X_2\beta_2{}',X_3\beta_3{}',X_4\ \beta_4{}', X_5\ \beta_5{}',X_6\ \beta_6{}', X_7\ \beta_7{}',X_8\ \beta_8{}', \rho)$$
$$= \Pr(\varepsilon_{1i} \le X_1\ \beta_1{}',\ \varepsilon_{2i} \le X_2\beta_2{}',\varepsilon_{3i} \le X_3\beta_3{}',\varepsilon_{4i} \le X_4\ \beta_4{}',$$
$$\varepsilon_{5i} \le X_5\ \beta_5{}', \varepsilon_{6i} \le X_6\ \beta_6{}', \varepsilon_{7i} \le X_7\ \beta_7{}', \varepsilon_{8i} \le X_8\ \beta_8{}' \quad (6)$$

Where Φ_m is multivariate standard normal distribution

To estimate the interdependence of household decision to adopt climate change adaptation strategies, the above equation was used with eight endogenous variables.

2.3 Variables definition and hypothesis

2.3.1 Dependent variable for Multivariate probit model

The choice of adaptation strategies from the set of adaptation options in multivariate probit model are assumed to be done among the most prevalent adaptation mechanism in the study area. Changing planting dates, changing crop varieties, changing crop types, using irrigation, soil and water conservation practices are some of these adaptation mechanisms and options for climate change in rain-fed agriculture of many African countries (Nhemachena and Hassan, 2007). The adaptation choices for this study are based on the asking sample households the actions taken to counterbalance the negative effect of climate change.

2.3.2 Independent variables for Multivariate probit model

The explanatory variables for this study are those factors which are expected to affect smallholder farmers' choices of adaptation strategies against climate variability.

Dependency ratio is a continuous variable ranging between zero and one, which refers to the number of family members which are dependent.

Land holding (ha) is a continuous variable measured in hectares. Hassan and Nhemachena (2008) reported that larger farm size was found to encourage the use of multiple cropping and integration of a livestock component, especially under dry land conditions. Large land holdings allow farmers to diversify their crop and livestock options and help spread the risks of loss associated with changes in climate. Since land holding is associated with greater wealth, the study hypothesized land holding has positive relation crop diversification with adaptation option to the climate change.

Cooperative membership:

Credit: it is a dummy variable that takes a value of 1 if received credit and 0 otherwise. Availability of credit eases the cash constraints of households and allows purchasing inputs like fertilizer, improved crop varieties, irrigation facilities and so on. Credit access and use has a positive impact on climate change and variability adaptation strategies (Aemiro et al., 2012).

Location: is dummy variable that takes a value of 1 and 0 otherwise. Farmers living in different agro ecological zones make use of different adaptation strategies (Temesgen *et al.,* 2009; Aemero *et al.,* 2012,).

Frequency of contact with Extension agents: It is a discrete variable measured by the number of contacts made with extension workers in the year. It creates access to information and technical assistance on agricultural activities and adaptation methods through extension services. Access to extension services has a positive impact on the probability of adopting adaptation strategies to climate change and variability (Aemro *et al.,* 2012; Belaineh *et al.,* 2013).

Distance to market: is a continuous variable and measured in kilometers from home of the households to the nearest market. The closer the farmer is to the market the more likely the farmer receives valuable information and purchase agricultural inputs. Proximity to market is an important determinant of adaptation. A long distance to markets decreases the probability of farm adaptation in Africa due to market provides an important platform for farmers to gather and share information (Maddison, 2006).

Experience in using fertilizer and post harvest technologies have also an impact on climate variability adaptation strategies.

Table 1.
Variables used in the multivariate probit model and expected signs

Name of Variable	Type of variable	Unit of Measurement	Expected Sign
Dependence ratio	Continuous	Ratio	-
Total Land owned	Continuous	Ha	+/-
Cooperative membership	Dummy	yes=1,0=No	+
Credit access	Dummy	yes=1,0=No	+
Family size	continuous	No. of persons	+/-
District	Dummy	yes=1,0=No	+/-
No. of Extension Visit	Continuous	Number	+/-
Distance to Extension office	Continuous	Ha	+
Distance to grain market	Continuous	Hectares	+
Mixed crop-livestock farming system	Dummy	yes=1,0=No	+/-
Fertilizer use experience	Continuous	Years	+/-
Post harvest technologies use experience	Continuous	Years	+/-

3 Result and Discussion

3.1 Socio-economic characteristics

Majority of the sampled households (93%) were male headed while 7% were female headed households. The education level of the sampled respondents were skewed towards illiterate and elementary (1-4) school which accounts for 35.12 % and 34.63%, while 21.46% and 8.78 % of them were primary (5-8) and high school (9-10) complete respectively.

Based on proportional to size about 50% of the sampled households were from humid intermediate, 35% (crop livestock mixed farming system and highland and the remaining 15% were from humid lowland agro-ecology respectively.

Land is a constraining factor of production in agriculture. Land ownership has an effect on technology adoption, enterprise choice and market orientation. Due to demographic, economic, institutional and environmental factors, the demand for agricultural land is increasing at an alarmed rate. Cognizant of this fact, the government of Ethiopia has currently recognized the importance of land as a key strategic resource to drive smallholders out of poverty. Hence, land use and ownership pattern has an effect on impacts of climate change. According to the survey results, the land holding pattern of the households is the same in all cases except slight change in self owned cultivated land and self owned total land with slight increase (up 50 %) and slight decrease (< 50%) towards cultivation and ownership in the last ten years. The total share cropped and cultivated land showed slight increase. Thus, this indicates that in the farmers are searching alternative land use patterns to solve land shortage for agricultural production activities.

Furthermore, it is important to note that self owned cultivated land showed greater variability due to the fact that the farmers have started cultivating fallow land due to the increase in their family size, decrease in fertility of their farm land and increase in crop diversification to minimize risk. In addition, about 14.15% and 6.83% of the households revealed that self owned cultivated land is decreased by less than 50% and > 50 % in the last ten years. This may be due to low soil fertility status and acidity problems of their farmland, the farmers have abandoned cultivating their land. This needs an urgent solution to reclaim their farm land through sustainable soil and water management techniques to enhance land production and productivity.

Table 2.
Land Holding pattern of the Households since the last 10 years

Variable	Increase (>50%)	Increase (up to 50 %)	Same	Decrease (<50%)	Decrease (>50%)
Self owned total land	3.90	12.2	67.78	13.17	1.95
Self owned cultivated land	4.39	20.49	54.15	14.15	6.83
Rented in total land	0.49	2.93	96.10	0.00	0.49
Rented in cultivated land	0.98	1.95	96.58	0.00	0.49
Total share cropped land	2.44	5.85	87.32	2.44	1.95
Share cropped cultivated land	1.95	6.34	85.37	3.41	2.93

Source: survey results, 2016

3.2 Knowledge and Impact of Climate change

About 85.85% have been observed heavy rainfall while 14.15% of the respondents did not in their locality. Complement to the above fact, about 94.63% of the respondents did not observe very short rain while 5.37% of them did. This indicates that heavy rainfall is the major climate change problem in the crop-livestock mixed farming system in Benishangul-Gumuz region. Moreover, about 48.78 % of the sampled households responded that increased/high temperature is the major problem of climate change.

Furthermore, the incidence of diseases and pests is also the big challenge for smallholder farmers in the study areas. It seems logical that with excessive/ high rainfall complemented with increased temperature creates favourable condition for disease and pests. For this reason the humid intermediate and lowland agro-ecological zones of Benishangul-Gumuz region are hot spot for major crop and livestock diseases and pests.

Farmers’ perception regarding climate change effects are presented at the following table. Perceptions on the effect of climate change mainly due to increased/high temperature and excessive rainfall is indicated at Table 3. The major effects of climate change were hotness of the body (55.61%), other manifestation of rainfall (erratic and heavy during shower season) (49.27%), changing the environment (deforestation and wild fire (33.17%)), heavy rainfall during flowering and seed setting (31.22%) and excessive heating (30.73%) as indicated in Table 2 below.

Table 3.
Effects of Climate Change

Indicators of climate change effects	Frequency	
	Yes	No
leads to hotness of the body	114 (55.61)	91(44.39)
Health illness	65 (31.71)	140 (68.29)
Changing the environment	68 (33.17)	137(66.83)
Excessive heating	63 (30.73)	142 (69.27)
Reduces the rain-fall amount	9 (4.39)	196(95.61)
Human skin	29 (14.15)	176(85.85)
Animal death	34 (16.59)	171(83.41)
Other problems	22(10.73)	183(89.27)
heavy rainfall at planting	48 (23.41)	157(76.59)
low rainfall at planting	14 (6.83)	191(93.17)
Absent of rainfall at flowering /pod seed setting	28 (13.66)	177(86.34)
Heavy rainfall at harvest	51(24.88)	154 (75.12)
High rainfall at flowering seed setting	64(31.22)	141(68.78)
Other manifestation of rainfall	101(49.27)	104(50.73)
unseasonal rainfall	13(6.34)	192(93.66)
Households' observation on climate change		
Heavy rainfall	176 (85.85)	29 (14.15)
Short rainfall	11 (5.37)	194 (94.63)
High temperature	100 (48.78)	105(51.22)
Incidence of new diseases and pests	100 (48.78)	105(51.22)
Low temperature	28(13.66)	177(86.37)

Source: survey results, 2016

To measure the impact of climate change we use percentage loss due the causes of climate change indicators as a proxy. Thus, crop diseases and pests had caused about 50.56% yield losses; excessive/high rainfall had 39.31% crop yield losses; livestock diseases cause about 27.1 % livestock death.

Table 4.
Impact of climate change effects total loss (percentage) on crop and livestock

Components of climate change	total loss (percentage)	Effects				
		Very negative	Negative	No effect	Positive	Very positive
Increased precipitation	39.31	49.27	31.71	11.71	6.34	0.99
Decreased Precipitation	17.02	13.17	33.17	51.71	42.44	1.95
Increased variability in precipitation	18.11	18.05	34.63	44.87	1.95	0.49
Decreased run-off	0.87	1.95	0.49	75.16	16.10	5.85
Increase runoff	17.38	18.54	31.71	49.67	0	0
Run-off Variability	6.55	7.32	18.54	74.13	0	0
Increased in temperature	12.16	10.73	27.80	60.97	0.49	0
Decrease in temperature	5.20	2.93	17.07	75.61	2.44	1.95
Increased risk of droughts	19.83	23.41	16.10	60.00	0.49	0
Crop diseases, insect pests infestation	50.56	61.95	29.27	8.78	0	0
Livestock diseases	27.10	35.12	12.20	52.68	0	0

Source: survey results, 2016

Moreover, drought (late rain-offsetting) variability in rainfall, increased run-off due to high rain fall decreased rain-fall and high temperature had caused about 19.83%, 18.11%, 17.38%, 17.02% and 12.16% yield losses respectively as indicated in Table 4.

About 61.95% of the farmers perceived that crop diseases, insects and pests infestation had very negative effects while 49.47%, 35.12% and 23.41% of the farmers perceived that increase in precipitation, livestock disease, and increased risk of drought had very negative impacts on crop and livestock production respectively. Finally, variability (decreased and increased) in precipitation, increased runoff, increased temperature, crop diseases and pests infestation had also negative effects (see table 4).

Farmers perception regarding climate change in the last ten and five years is indicated at the table below. The results showed that Increase in diseases, insect pests infestation in the last ten and five years have been frequently happened with a value of 4.38, and 3.13 times on average respectively and followed by increase in precipitation and temperature (see table below).

Table 5.
Frequency of Indicators of climate change variables and long term perceptions

Indicators of climate change variables	Change over the last		Perception/future expectation				
	Ten years	Five years	No response	High	Low	Same	Do not know
Increase in precipitation	1.86	1.54	4.88	46.83	6.83	2.44	39.02
Decrease in precipitation	0.75	0.47	17.07	4.39	16.59	1.95	60.00
variability in precipitation	1.20	0.89	13.66	13.17	9.76	2.93	60.49
Increase in flood frequency	0.96	0.56	20.98	2.44	5.85	29.27	67.80
decrease in flood frequency	0.2	0.17	25.85	0.49	2.93	3.41	67.32
Increase in drought frequency	0.27	0.14	91.71	5.85	0.49	0.98	0.98
decrease in drought frequency	0.23	0.21	26.83	0.49	2.44	2.93	67.32
Increase in temperature	1.65	1.32	18.54	18.05	2.93	4.88	55.61
decrease in temperature	0.54	0.40	22.44	4.88	3.90	1.46	67.32
Increase in diseases, insect pests infestation	4.38	3.17	3.90	41.95	11.71	2.44	40.00

3.3 Farmers Perception about long term climate variations

The farmers' perception regarding the long term perception on climate indicators showed that about 46.83% and 41.95% of the respondents revealed that increase in precipitation, increase in disease and insect pests respectively were the major worries for the future. However, it must be noted that majority of the farmers do not respond and replied only Almighty God knows about the future.

3.3.1 Temperature

The trend analysis between average annual temperature and time for Bambassi district indicated that average annual temperature in the study area decreased by about 0.308 °C each year (Figure 1).The trend analysis between average maximum temperature and time for Bambassi district indicated that average maximum temperature in the study area increases by about 0.116 °C each year. Moreover, the trend analysis between mean minimum annual temperature and time also shows an increase in one year time results in a decrease in the minimum temperature of the Bambassi disrict by 0.732 °C. The farmers' perceptions appear to be in accordance with the statistical record of the area.

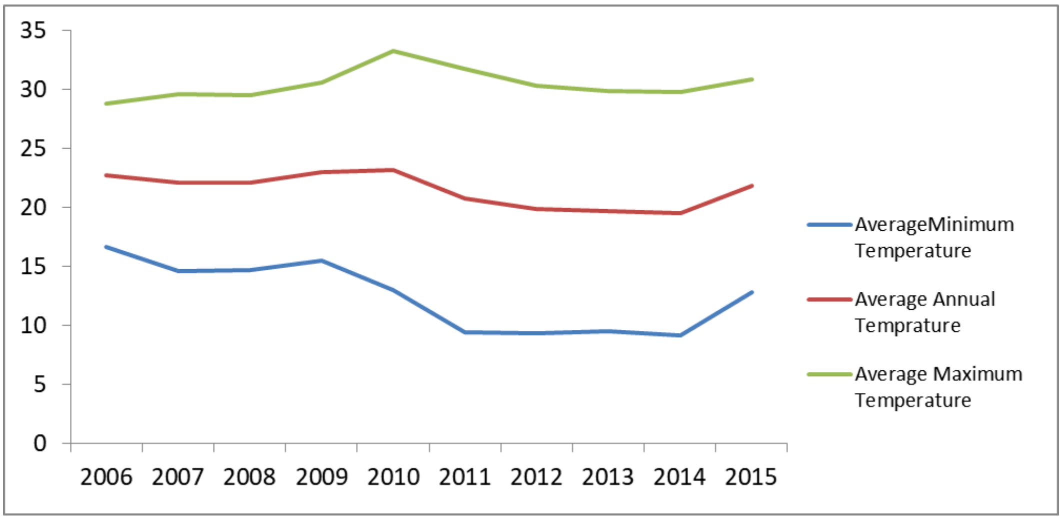

Figure 1. Average Minimum, Annual and Maximum Temperatures for Bambassi District from 2006-2015

The trend analysis between average annual temperature and time for Kamashi district indicated that average annual temperature in the study area has increased by about 0.16 °C each year (Figure 2).The trend analysis between average maximum temperature and time for Kamashi district indicated that average maximum temperature in the study area increases by about 0.063 °C each year. Moreover, the trend analysis between mean minimum annual temperature and time also shows an increase in one year time results indicated that increased trend in the minimum temperature of the Kamashi disrict by 0.256 °C.

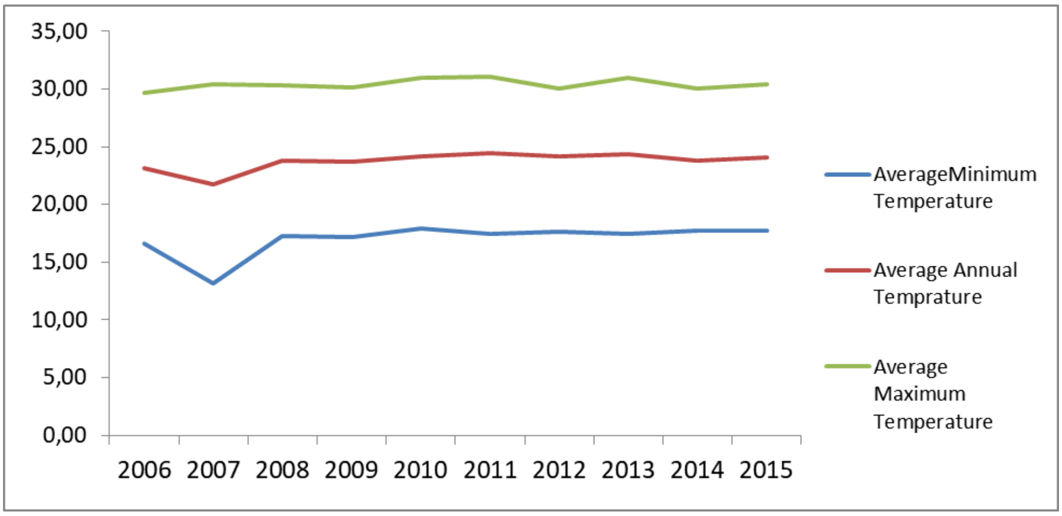

Figure 2. Average Minimum, Annual and Maximum Temperatures for Kamshi District from 2006-2015

The trend analysis between average annual temperature and time for Mao-Komo district indicated that average annual temperature in the study area has increased by about 0.106 °C each year (Figure 3).The trend analysis between average maximum temperature and time for Mao-Komo district indicated that average maximum temperature in the study area increases by about 0.010 °C each year. Moreover, the trend analysis between mean minimum annual temperature and time also shows an increase in one year time results in a increases in the minimum temperature of the Mao-Komo disrict by 0.203 °C.

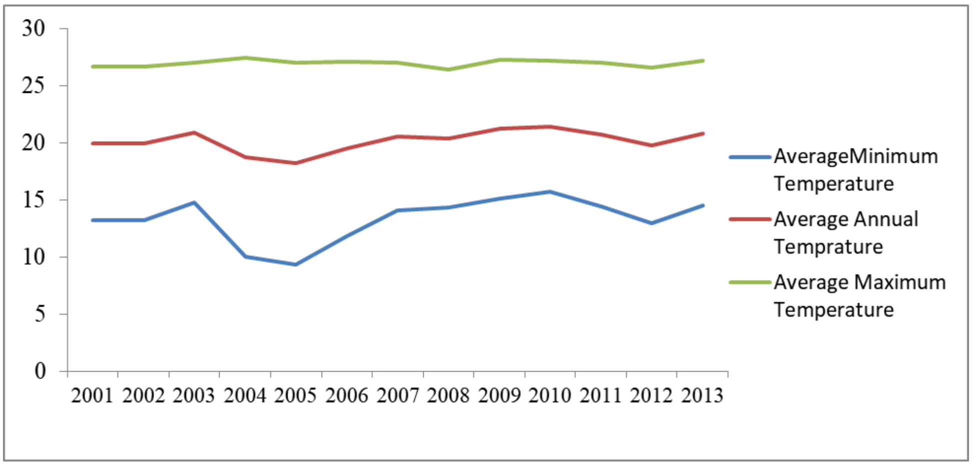

Figure 3. Average Minimum, Annual and Maximum Temperatures for Kamshi District from 2006-2015
Source: Computed based on data obtained from National Meteorological Agency, Assosa branch

3.3.2 Precipitation

The trend analysis between annual rainfall and time using data obtained from meteorology agency indicated that annual rainfall in the Bambasi has increased by about 0.36 mm each year (Figure 4). The low coefficient of determination also showed that there in rainfall variability for ten years.

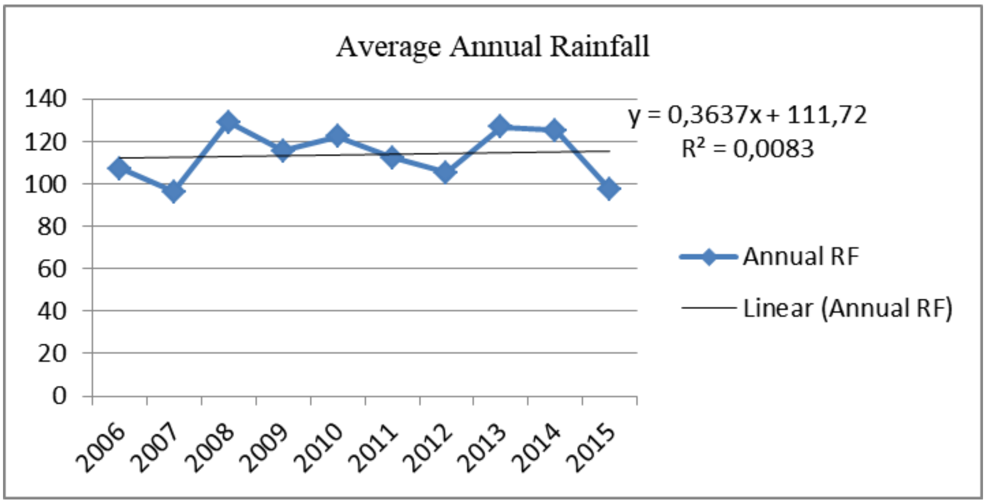

Figure 4. Annual Rain fall for Bambassi district

The trend analysis between annual rainfall and time using data obtained from meteorology agency indicated that annual rainfall in Kamashi district has decreased by about 9.13 mm each year (Figure 5).

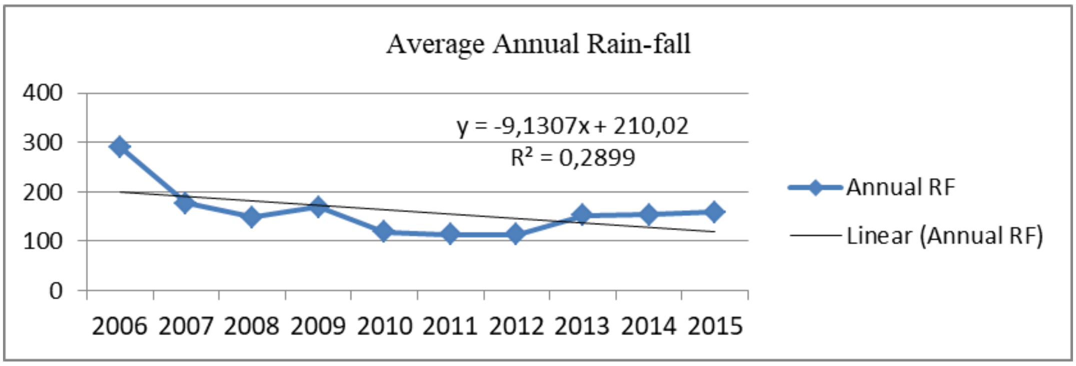

Figure 5. Annual Rain fall for Kamashi district

The trend analysis between annual rainfall and time using data obtained from meteorology agency indicated that annual rainfall in Mao-komo district has decreased by about 1.74 mm each year (Figure 6).

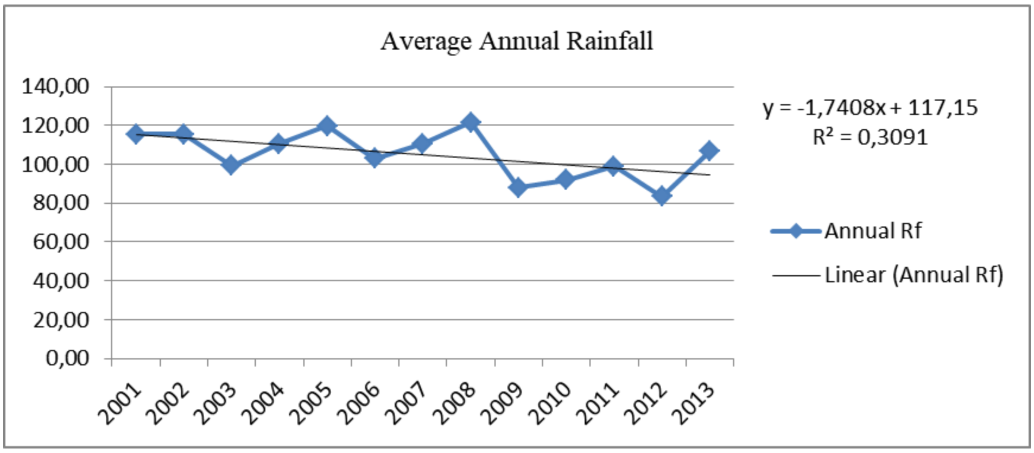

Figure 6. Annual Rain fall for Mao-Komo district

3.4 Sensitivity of Agricultural Technologies to climate change

The national and regional research institutes have released different crops and forage varieties and adopted by smallholder farmers. Hence, the released agricultural technologies should be resistance to climate variability, diseases outbreak, and other biotic and abiotic factors and contributions to mitigate climate change.

The mainly used improved varieties of maize were BH-540, BH-660, BH-140, BH-543 and Shone varieties. Accordingly, Shone were less sensitive to climate variability relative to other varieties. Moreover, BH-543 was highly susceptible to climate variability followed by BH-140 and BH-660 and 540 respectively. This indicates that BH-140 and BH-543 were highly susceptible to strike virus and blight and BH-540 was susceptible to wind and heavy rain. Consequently, we suggest that during technology generation process farmers should participated in technology selection and evaluation to consider their needs. The same interpretation goes to other crop improved varieties as indicated in the table below. The table further indicates among the respective adopted improved varieties of potato (Gudene), groundnut (maniputer), Soybean and forage (Rodus) were less sensitive to climate variability.

Table 6.
Sensitivity of Agricultural Technologies to climate change

Crop Type	Variety Name	Sensitivity			
		Very sensitive	Sensitive	Slightly sensitive	Not sensitive
Maize	BH-540	33.33	30.56	25.00	11.11
	BH-660	41.67	25.00	25.00	8.33
	BH-140	50.00	50.00	0.00	0.00
	Shone	16.39	8.20	27.87	47.54
	BH-543	100.00	0.00	0.00	0.00
Teff	Kuncho	26.09	26.09	39.13	8.70
Wheat	Dandaa	41.67	33.33	16.67	8.33
	Digalu	16.67	16.67	25.00	41.67
Soybean	Belesa-95	16.92	23.08	24.62	35.38
Pepper	Markofana	80.00	20.00	0.00	0.00
Rice	NERICA-4	40.00	20.00	40.00	0.00
Groundnut	Maniputer	57.14	0.00	0.00	42.86
Potato	Gudene	0.00	0.00	0.00	100.00
Forage	Oat	0.00	0.00	100.00	0.00
	Rodus	0.00	33.33	33.33	33.33

Source: survey results, 2016

3.5 Determinants of Adaptation Measures to Climate Change

The result of MVP model is presented in Table 7. The results of the correlation coefficients of the error terms are significant for the pairs of equations. This indicates that there are complementarities (positive correlation) between different adaptation options being used by farmers. The chi-square ($\chi2$) distribution is used as the measure of overall significance of a model in probit model estimation. The log likelihood of (831.88) the probability of the chi-square distributions (240.52) with 104 degree of freedom less than the tabulated counterfactual is 0.0000, which is less than 1% shows that, the variables included explaining climate change strategies fits best the model at less than 1% probability level and shows that, the data fits the model very well.

Dependency ratio had a significant ($p<0.01$) and negative effect on the likelihood of participation decision in the climate adaptation options specifically to the adoption of different improved varieties as expected. Thus, economically active household members significantly affect the decision of adoption of improved crop varieties. The coefficient of -1.5 suggests that if the household productive labor size increases by one percent, the likelihood to adopt different crop improved varieties increases by 150% holding all other variables in the model constant. This is due to the behavior of agricultural activities (crop production) is labor intensive where households with more family labor could adopt different improved varieties as improved varieties demand good management practices to give the expected outputs.

Family size had a significant ($p<0.05$) and positive effect on the likelihood of participation decision to use irrigation in the climate adaptation option. This may be the due to households with large family size would have enough labour for irrigation and rain-fed agricultural activities. This result is in line with Temesgen *et al.* (2008); Belaineh *et al*. (2013); and Seid et al., (2016) and found that family size had an effect on climate change adaptation options.

Total land ownership increases the probability of adoption of different improved crop varieties and changing capital and labour at the probability of level of 0.05. The logic behind is as farmers with large land have more advantage to adopt different improved varieties and changing capital and labour. This result is in contrast with the results of Temesgen et al., 2008 and seid et al., (2016). However, it is consistence with the results of Hassan and Nhemachena, (2008) and found that large land ownership allows farmers to spread the risk of farmers associated with climate.

Farmers with access to credit have higher chances of adapting to changing climatic conditions. Access to affordable credit increases financial resources of farmers and their ability to meet transaction costs associated with the various adaptation options. Access to financial and other resources at the disposal enables farmers to change their management practices in response to climate change. Hence, access to credit had significant and positive effect on the use of irrigation, changing capital and labour, use of chemicals to protect diseases, insect and pests and adjustment in planting dates thereby enabling farmers to buy farm chemicals, new irrigation technologies, and other important inputs and machineries that may need to change their practices to suit the forecasted and prevailing climatic conditions. Similar results were reported by Nhemachena and Hassan, (2007); Hassan and Nhemachena, (2008); Temesgen *et al*. (2009); Seid et al., (2016) and found that access to credit had a significant effect on climate change adaptations strategies uptake.

Agro-ecology increases the probability of farmers to respond to changes in terms of crop diversification, changing use of irrigation and ground water, use of different improved varieties, management practices. Thus, farmers living at humid intermediate and highland agro-ecologies were used different options so as to mitigate impacts of climate change and intervention needs to be done based on the resources endowments and appropriateness of the mitigation strategies across different agro-ecologies. For example, these agro-ecologies have excess rainfall and high temperature. Hence, priority should be given to long maturing varieties development. The results resembles to the findings of Aemiro et al., 2012; and Belaineh et al., (2013).

Extension visit had significant effect on climate change adaptation options like crop diversification, adoption of improved varieties, and use of irrigation. Farmers frequently visited by development agents had high likelihood to participate in climate change strategies while unlikely to participate in irrigation water use. This may be due to the extension contacts may not be necessarily on irrigation rather on rain-fed crop production and another agricultural activities and it implies that extension services on irrigation and water use should be promoted jointly with another extension services. The finding is in line with Temesgen et al., (2009), Belaineh et al., (2013) Yegbemey et al., (2014).

Distance to grain market and extension services had also an effect on the climate change adaptation options. Thus, access to market places and extension services contributes to minimize risks occurred at pre and post harvest. This could be achieved through expansion of road infrastructure and creating linkage among value chain actors. The finding is similar with Madisson (2006); and Temesgen (2010).

Farmers experience in using fertilizer had an effect on crop diversification adaptation option. Thus, experience on the use of fertilizer could enable farmers to improve the knowledge of farmers on the application rate and fertilizer requirements crops. Hence, experienced farmers would have better knowledge on the crop fertilizer applications and time of applications. This could finally enable them to adapt to climatic conditions in variable rainfall and temperature changes.

Mixed crop and livestock farmers are associated with positive and significant adaptation to changes (capital and labour) in climatic conditions compared to specialized crop and or livestock farmers due to the nature of the mixed farming system. For example, livestock asset ownership could help to minimize risk in case of crop failure and vis-à-vis. Moreover, the two types of enterprises are complements each other in many cases. Consequently, the results imply that mixed farming systems are better able to cope with changes to climatic conditions through undertaking various changes in production practices. This result is in line with results of Nhemachena and Hassan, (2007). Moreover, Holzkämper A., (2017) agreed that climate change poses a challenge to production and its impacts vary depending on regional focuses and on the type of production system.

Farmers experience in using post harvest technologies had an effect to up take different climate adaptation options as farmers experience in farming increased the use of post harvest techniques and technologies would be enhanced. Furthermore, as the use of post harvest technologies experience is increased; adoption of improved varieties would be enhanced as the farmers' knowledge and skills in pre harvest and post harvest management is improved.

Table 7.
Determinants of Climate change adaptation strategies

Variables	**Climate change Adaptation Strategies**							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	CD	IRR	DIFIM	LANDC	CKL	CHSP	RIDG	DIFPLD
	Coef (Std.Err)	Coef (Std.Err)	Coef (Std.Err)	Coef (Std.Err)	Coef (Std.Err)	Coef (Std.Err)	Coef (Std.Err)	Coef (Std.Err)
Dependence ratio	-0.73 (0.45)	0.64 (0.46)	-1.5*** (0.45)	-0.25 (0.46)	-0.32 (0.51)	-0.64 (0.43)	0.34 (0.45)	-0.19 (0.46)
Tot. Land (ha)	0.06 (0.04)	-0.07 (0.05)	0.11** (0.04)	0.08 (0.05)	0.09** (0.05)	-0.01 (0.04)	-0.01 (0.04)	0.07 (0.04)
Coop. Memb.	0.45* (0.25)	0.001 (0.26)	0.21 (0.24)	0.42* (0.25)	-0.07 (0.26)	0.33 (0.24)	0.32 (0.25)	0.48** (0.24)
Credit access	0.06 (0.23)	0.61*** (0.23)	0.35 (0.23)	0.39* (0.23)	0.58** (0.25)	0.49** (0.22)	0.38 (0.23)	0.45** (0.23)
Family size	0.01 (0.03)	0.08** (0.03)	0.006 (0.03)	-0.04 (0.04)	0.03 (0.04)	-0.03 (0.03)	0.04 (0.03)	0.05 (0.03)
Bambassi	0.74** (0.31)	1.74*** (0.46)	-0.28 (0.31)	0.40 (0.32)	0.52 (0.36)	0.72** (0.31)	0.93*** (0.31)	0.48 (0.33)
Mao-Komo	0.63*(0.33)	1.63*** (0.46)	0.61* (0.33)	0.21 (0.35)	-0.04 (0.41)	0.51 (0.31)	0.44 (0.32)	0.45 (0.35)
No. of Extn. visit	0.03* (0.016)	-0.001* (0.013)	0.03** (0.02)	-0.012 (0.016)	-0.004 (0.05)	-0.005 (0.013)	0.013 (0.026)	0.016 (0.013)
Dist.Extn office (km)	0.01 (0.07)	0.10 (0.07)	0.007 (0.07)	0.08 (0.07)	0.21*** (0.08)	-0.04 (0.07)	0.073 (0.072)	0.16** (0.07)
Dis. grain mkt (km)	-0.50 (0.31)	-0.047** (0.02)	-0.03* (0.02)	0.002 (0.018)	0.004 (0.02)	-0.01 (0.02)	-0.01 (0.016)	-0.001 (0.018)
FS	-0.11 (0.25)	-0.16 (0.28)	-0.002 (0.27)	-0.07 (0.26)	1.01*** (0.36)	0.04 (0.25)	0.36 (0.25)	0.40 (0.26)
Fert. use exp. (years)	0.07*** (0.02)	-0.02 (0.026)	0.023 (0.024)	0.008 (0.03)	0.005 (0.03)	0.04* (0.02)	0.004 (0.04)	-0.03 (0.023)
PHT use exp. (years)	-0.01 (0.02)	0.01 (0.02)	0.07*** (0.02)	0.07*** (0.03)	0.03* (0.02)	0.013 (0.015)	-0.02* (0.015)	-0.004 (0.015)
_Const	-0.55 (0.44)	-2.2*** (0.58)	-0.43 (0.42)	-.86 (0.45)	-2.6*** (0.58)	-0.58 (0.43)	-1.12** (0.45)	-2.0*** (0.49)
Predicted probability	0.54	0.46	0.40	0.27	0.23	0.45	0.64	0.38
Observations			204					
Log likelihood			-831.88					
Wald chi2 (104)			240.52					
Prob>Chi2			0.0000					
Joint probability of success			0.02					
Joint probability of failure			0.06					

rho21=-0.067; rho31=0.764***; rho41= 0.320**; rho51= 0.265*; rho61=0.022; rho71=0.084; rho81=0.289***; rho32=0.102; rho42=0.195* ; rho52=-0.104; rho62=-0.131; rho72=0.006; rho82=0.006; rho43=0.400***; rho53=0.352***; rho63=0.168; rho73=0.287**; rho83=0.255**; rho54= 0.563*** rho64=0.104; rho74=0.215*; rho84=0.206***; rho65=0.179; rho75=0.206; rho85=0.306**; rho76=0.149; rho86=0.307***; rho87=0.181
N.B: ***, **,* indicates significant levels at 1%, 5% & 10% respectively.

3.6 Interactions of climate change adaptation decisions

The expected multivariate interdependence of climate change adaptation strategies like crop diversification, use of irrigation, adoption of different crop improved varieties, land change, capital and labor change, use of chemical spraying, using soil and water conservation techniques like ridging and changing planting date was accounted for by employing the multivariate probit simulation of the participation decision of the eight adaptation strategies (Table 7).

The results revealed that, change in farm land use, change in capital and labor; use soil and water conservation techniques and planting date had positive and significant interaction with adoption of improved crop varieties. This is not actually surprising due the nature of the climate change adaptation option are complements with each other. Land use change had also positive and significant interaction with change in capital and labor, use of soil and water conservation techniques and using different planting date. Moreover, there was positive and significant interaction between adjustments in planting date and use of capital and labor change and use of chemical spray during disease and pests incidence. From the interdependence analysis we found that that the climates change adaptation strategies were complements to each other. Hence, promotion and intervention on one strategy would have a synergetic to reduce the impact of climate change effects.

Table 7 revealed that the predicted, joint success and failure probabilities of the households' decision to choose the climate change adaptation strategies. The predicted probability (likelihood) of using soil and water conservation techniques like ridging was 64 % which is high comparing to the others. This finding is similar to Seid et al., (2016). The likelihood of decision to choose crop diversification, use of irrigation, adoption of improved varieties, change in land use, change in capital and labor, use of chemical spraying and using different planting date were 54 %, 46 %, 40 %, 27 %, 23 %, 45 %, and 38 % respectively. The small predicted probability level may indicate that though there is high demand for capital and land use change, due to limited access to land and capital (small amount of credit) the households were less likely to participate in the climate change adaptation options.

Furthermore, the joint probability showed that, if households were able to choose all eight strategies, their joint likelihood of choosing these strategies would be only 2%. It was unlikely for households to choose all strategies simultaneously. This was justified either by the fact that simultaneous adoption of all the option was impossible for the farmers, or that all the strategies were not simultaneously adopted across the different agro-ecologies.

Moreover, the joint probability of not choosing all options by the households was also 6 %, implying that the households have participated at least one climate adaptation option. This evidence suggests the need to launch a package and scheme of climate change mitigation strategies based on the resources availability of smallholder farmers.

4 Conclusions and Policy Implications

This study was focused on the choice of farmers make in response to climatic variations, institutional and economic factors. The descriptive statistics results confirmed that crop technologies adaption has reduced losses due to climate change relatively to the non-adopters The decision of the farmers was influenced by different socio-economic and institutional factors that include household characteristics, resource endowments and access to institutional factors which are important for smallholder farmers to minimize risk of climatic variations. The farmers' perception about the long term climatic change variations on long term change in temperature and precipitations is high. As a result, crop management practices and technology generation process must target at precipitation tolerant crop varieties.

Important adaptation options being used by farmers include crop diversification, using different improved crop varieties, changing planting and harvesting dates, increased use of irrigation, increased use of water and soil conservation techniques, changing planting dates, and changing land under cultivation, capital and labour. It is important to note that these adaptation measures should be taken in a complementary ways. Supporting farmers in increasing these adaptation measures through providing the necessary resources such as land, credit, providing adequate extension services and information and training on pre and post harvest technologies can significantly help farmers' technology adoption even under changing climatic conditions. Government policies need to support research and development that develops and diffuses the appropriate technologies to help farmers adapt to changes in climatic conditions. Government responsibilities are usually through conscious policy measures to enhance the adaptive capacity of agricultural systems.

References

Aemiro, T., Jema, H., Mengistu, K. (2012). Climate Change Adaptation Strategies of Smallholder Farmers: The Case of Babilie District, East Harerghe Zone of Oromia Regional State. *Journal of Economics and Sustainable Development*, **6**(17): 1-12.

Belaineh, L., Yared, A., Woldeamlak, B. (201). Smallholder farmers' perceptions and adaptation to climate variability and climate change in Doba district, west Hararghe, Ethiopia. *Asian Journal of Empirical Research,* (3): 251-265.

Belderbos, R., Carree, M., Diederen, B. Lokshin, B., Veugelers, R. (2004). Heterogeneity in R&D cooperation strategies. *International Journal of Industrial Organisation* **22**: 1237-1263.

Brohan, P., Kennedy, J.J., Harris, I., Tett, S.F.B., Jones, P.D. (2006). Uncertainty estimates in regional and global observed temperature changes: A new data set from 1850. *Journal of Geophysical Research Atmospheres*, **111**: D12106.

Cameron, C., Trivedi, T.K. (2009). Micro-econometrics using Stata. StataCorp Ltd, Texas, USA.

Cappellari, L., Jenkins, S. (2003). Multivariate probit regression using simulated maximum likelihood. *The Stata Journal, **3**(3): 278–294.*

Chib, S., Greenberg, E. (1998). Analysis of multivariate probit models. *Biometrika*, **85**(2): 347–61.

Crosson, P. (1983). A schematic view of resources, technology and environment in agricultural development. *Agriculture, Ecosystems and Environment*, ***9***: 339–357.

Degye, G., Belay, K., Mengistu, K. (2013). Is food security enhanced by agricultural technologies in rural Ethiopia? *AfJARE*, **8**(1): 58-68.

Dercon, S. (2004). "Growth and Shocks: Evidence from Rural Ethiopia." *Journal of Development Economics*, **74**(2):309–329.

Greene, W.H. (2012). Econometric analysis. Seventh edition. New Jersey: Pearson Hall.

Hassan, R., Nhemachena, C. (2008). Determinants of African farmers' strategies for adapting to climate change: Multinomial choice analysis", *AfJARE*, **2**: 83-104.

Holzkämper, A.(2017). Adapting Agricultural Production Systems to Climate change; what's the Use of Models? *Agriculture*, **7**: 86.

Houghton, J.T., Jenkins, G.J., Ephrams, J.J. (1990). *IPCC scientific assessment of global climate change.*Geneva and Nairobi: World Meteorological Organization and United Nations Environmental Program.

Jagtap, S. (2007). Managing vulnerability to extreme weather and climate events: Implications for agriculture and food security in Africa. Proceedings of the International Conference on Climate Change and Economic Sustainability held at NnamdiAzikiwe University, Enugu, Nigeria. 12-14 June 2007.

Lin, C-T.J., Jensen, K.L., Yen, S.T. (2005). Awareness of foodborne pathogens among US consumers. *Food Quality and Preference,* **16**: 401-412.

Long, J.S., Freese, J. (2005). Regression models for categorical dependent variables using Stata. Second edition. USA: Stata Press, Texas.

Long, J.S. (1997). Regression models for categorical and limited dependent variables (RMCLDV). Thousand Oaks CA: Sage Press.

Maddala, G.S. (1983). Limited-dependent and qualitative variables in econometrics. Cambridge: Cambridge University Press.

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.

NMA (National Meteorological Agency) (2007). Climate change technology needs assessment report of Ethiopia, Addis Ababa, Ethiopia.

Nwafor, M, Adenikinju, A., Ogujiuba, K. (2007). The impact oftrade liberalization on poverty in Nigeria: dynamic simulationsin a CGE Model. RePEc:lvl:mpiacr:2007-16. Retrieved on19th November, 2010 from File URL: http://portal.pep-net.org/documents/download/id/8341

Reilly, J.M., Fuglie, K.O. (1998). Future yield growth in field crops: what evidence exists? *Soil and Tillage Research*, **47**: 275–290.

Rosenberg, N. J. (1992). Adaptation of agriculture to climate change.*Climatic Change*, **21**,: 385–405.

Seid, S., Jema, H., Degye G. (2016). Climate Change Adaptation Strategies of Smallholder Farmers: The Case of Assosa District, Western Ethiopia. *Journal of Environment and Earth Science,* **6**(7): 9-15.

Temesgen, D. (2010). Factors Affecting the Choices of Coping Strategies for Climate Extremes. Environment and Production Technology Division. IFPRI discussion paper 01032.

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

Temesgen D., Hassan, R.M., Ringler, C., Tekie, A., Mahmud, Y. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global Environmental Change,* **19**: 248-255:

United Nations Development Programme (UNDP) (2007) Adaptation LearningMechanism: learning through sharing experience. www.adaptationlearning.net

USDA (1990). *The second appraisal.*Washington, DC: United States Department of Agriculture (Miscellaneous Publication No 1482).

Yegbemey, R.N.; Yabi, J.A.; Aïhounton, G.B., Paraïso, A. (2014). Simultaneous modelling of the perception of and adaptation to climate change: The case of the maize producers in northern Benin. *Cah. Agric*., **23**(3): 177–187.

Ziervogel, G., Nyong, A., Osman, B., Conde, C., Cortes, S., Dowing T. (2006). Climate variability and change: implications for household food security. Assessments of Impacts and Adaptations to Climate Change (AIACC) Working Paper No. 20, January 2006. The AIACC Project Office, International START Secretariat, Washington DC, USA.

Appendix

Total sampled households

District	Total no of households	nTotal	~n
Mao-komo	8,554	70.25267	71
Bambasi	12,539	102.9809	103
Kamashi	3,552	29.17202	31
Total	24,645	202.4055	205