academicJournals

Vol. 10(9), pp. 956-964, 26 February, 2015
DOI: 10.5897/AJAR2014.9146
Article Number: 9A1563251045
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Farmers' climate change adaptation options and their determinants in Tigray Region, Northern Ethiopia

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Received 13 September, 2014; Accepted 17 February, 2015

Exploring micro-level evidences is critical to fine tune effective adaptation options to cope with the adverse impact of climate change. In this regard, detailed studies on climate change adaptation options are not available in the study areas. Hence, the objective of this study was to assess farmers' climate change adaptation options and determinant factors that influence their choice. Data were collected from 253 respondents randomly using probability proportional to the sizes (PPS) of the population of each district and peasant association from which sample households to be drawn. Descriptive statistics were employed to assess adaptation options while the multinomial logit model (MNL) was used to identify factors influencing households' choices. The results revealed that farmers use change in crop type /variety, soil and water conservation practices, crop diversification, change in planting date and irrigation practices as climate change adaptation options. Educational level of the household head, age of the household head, sex of the household head, farm income, access to extension service, access to credit, access to climate information and agro-ecological settings were the most important determinant factors that affect significantly the choice of farmers to climate change adaptations. Therefore, an effort that enhances farmers' awareness to climate change and creates the capacity to adopt climate resilient options is an important strategy that should be considered by a variety of societal groups, including policy makers, and farmers support organizations.

Key words: adaptation options, climate change, determinants, multinomial logit model.

INTRODUCTION

There is a general consensus that the Earth's climate is undergoing changes, and observations are consistent with scientific expectations regarding the increasing concentrations of greenhouse gases in the atmosphere. The Intergovernmental Panel on Climate Change (IPCC) reported that there is a statistically significant increase in the global mean state of the climate or in its variance, and further increases are expected if carbon dioxide and

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greenhouse gas emissions are not controlled (IPCC, 2007). Human activities, such as burning of fossil fuels and deforestation, have altered the global climate, resulting in increased temperature and alter the amount, intensity and distribution of precipitation and sea level rising.

Like other African countries, Ethiopia is widely held as one of the most vulnerable countries to future climate change (Conway and Schipper, 2011). Ethiopia's economy is built predominantly on agriculture, which contributes 41% of the country's gross domestic product (GDP), employs 80% of the labor force and produces more than 80% of its foreign exchange earnings (You and Ringler, 2010; Gebreegziabher et al., 2011). Agriculture in Ethiopia is mainly rainfed that involves many subsistent and small-scale farmers (Deressa et al., 2009). This condition together with its geographical location, topography and low adaptive capacity, makes the country highly susceptible to the adverse impacts of climate change (Gebreegziabher et al., 2011).

Among the regional states of Ethiopia, Tigray Regional State has been vulnerable to climate change (stable change over a long period of time usually 30 year or more). Climate change is expected to increase the frequency and magnitude of natural disasters and extreme weather events. Observations revealed that mean minimum and maximum temperatures of the region for the period 1954 to 2008 have increased by 0.72 and 0.36°C per decade, respectively indicating that the region is warming faster than the national average of 0.25°C (Gebrehiwot and van der Veen, 2013). Moreover, mean annual rainfall has shown a decreasing trend (Teka et al., 2012; Gebrehiwot and van der Veen, 2013). The onset and rainfall cessation date has changed towards decreasing the length of growing period (Hadgu et al., 2013).

The degree to which an agricultural system is affected by climate change depends on its adaptive capacity. Indeed, adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damage, to take advantage of opportunities, or to cope with the consequences (Sahu and Mishra, 2013; Vincent et al., 2013). Farmers in the study area have a long history of responding to climate variability and change through various strategies. While it is not possible to say that past adaptations will be sufficient in the face of the expanded range of future climate change, they give a better idea of what is required to reduce the negative effects of climate change, and therefore can inform policy and practices (Vincent et al., 2013). Research on adaptation-climate change interaction have been conducted in different parts of Ethiopia (Deressa et al., 2009; Tesso et al, 2012; Legesse et al., 2013; Mulat, 2013; Tessema et al., 2013). However, the information obtained from these studies was not sufficient to represent the study area as most of the previous studies focused on different agroecologies with different social, institutional and ecological settings. Moreover, most of the studies (Deressa et al., 2009; Legesse et al., 2013) focused on issues at national or regional levels and hence lack details at the household or farm level.

Previous studies revealed that adaptation strategies are vary contextually and spatially (within communities and even within individuals) and identified adaptation measures do not necessarily translate from one area to another (Deressa et al., 2009; Legesse et al., 2013). As site-specific issues require site-specific knowledge, it is very important, therefore, to clearly understand what is happening at site or household level. In the absence of local level evidences, it is difficult to fine tune interventions geared towards achieving effective and efficient adaptation options to cope with the adverse impact of climate change at local level. However, detailed studies on climate change adaptation options are not available in the areas identified for this study. Therefore, the objectives of this study were to identify the types of climate change adaptation measures practiced by farmers and assess the determinant factors that influence farmers' choice of adaption options.

METHODOLOGY

Description of the study area

The study was carried out in three districts of the Tigray National Regional State of Ethiopia. The districts are Ganta-afeshum, Alamata and Enderta, which are situated at different agroecological zones. In general, Ethiopia has four traditional agro ecological zones (Deressa et al., 2009). These are *Bereha* (desert, below 500 m a.s.l.), Kolla (low land, 500 to 1500 ma.s.l.), *Weynadega* (middle land, 1500 to 2500 m a.s.l.) and *Dega* (highland, 2500 to 3500 m a.s.l.). Out of the four traditional agroecological settings of Ethiopia, the survey districts fall in three of them (*Dega, Weynadega, Kolla*). Accordingly, Ganta-Afeshum is classified as *dega* and *weynadega* with an altitude ranges from 2461 to 3290 m.a.s.l; and received an average annual rainfall of 584 mm and mean annual maximum and minimum temperature of 23.6 and 6.9°C, respectively.

On the other hand, Enderta district comprised of two major agro-climatic zones. A greater portion lies in the *Weynadega* altitudinal climatic zone with an elevation range between 1500 to 2300 m while a smaller portion in the eastern and western parts lay in the '*Kolla*' altitudinal climatic zone with elevation between 500 to 1500 m (Florence, 2008). This study considers mainly the *Weynadega* part and characterized with mean annual maximum and minimum temperature of 24.3 and 11.3°C, respectively and average annual rainfall of 601 mm and Alamata district is found in the most Southern zone of Tigray. It is located at 12°15'N latitude and 39°35'E longitude (Gebrehiwot, 2005). Topographically, Alamata is divided into western highland and eastern lowlands. The lowland area has an altitude of 1500 m.a.s.l or below (*kola*) and account about 75% of the district, while 25% of the district falls in the intermediate highlands (*weynadega*) and highland (*dega*) with an altitude ranges between 1500 to 3148 m.a.s.l. (Berhane et al., 2010).

In this particular study, the low land part is used to represent the *kola* agro-climatic zone with an average annual rainfall of 752 mm and mean annual maximum and minimum temperature of 29.9 and 15.2°C, respectively.

Table 1. Distribution of sample households in the study area.

District name	Peasant Association	Total No of HH	No of sampled HH	%
Ganta-Afeshum	Buckot	915	32	12
	Beati-Maimesanu	1228	42	17
		18106	74	29
Enderta	Shibta	1606	63	25
	Felegdae'ro	950	37	15
		24571	100	40
Alamata	Selambikalsi	1965	50	20
	Kulugize lemlem	1115	29	11
		19212	79	31
Total		61889	253	100

Source: Finance and Development Offices of the respective woredas (2011).

Data collection

An exploratory study was first carried out in order to have a clear insight and to identify priority issues to be focused for the formal survey. Through this survey, information about the agro-ecological and socioeconomic features of the study area were collected. To supplement the formal survey, checklist was prepared and administered across different social groups and actors of the study communities. The formal survey was then framed based on the insight gained during the exploratory phase. Accordingly, three districts representing all agroecological zones were first selected purposively. Then, two peasant associations from each district were randomly selected. Finally, a total of 253 farm households were sampled randomly using probability proportional to the sizes (PPS) of the population of each district and peasant association from which sample households to be drawn. To select sample households from the selected peasant associations, list of household heads has been used. The distribution of sample households in the study area is presented in Table 1.

Data analysis

Qualitative data obtained from interviews and group discussion and the review of documents were compiled, organized, summarized and interpreted through concepts and opinions. Both descriptive statistics and econometric model were used to analyse the data. Descriptive statistics such as mean, frequency of occurrences and percentage were computed to summarize the adaptation options used by farmers. Analytical tools such as the statistical package for social sciences (SPSS) version-12 and STATA-10 were used to summarize the data.

Econometric analysis

Due to its computational simplicity, the multinomial logit model (MNL) specification was used to model climate change adaptation behavior of farmers involving discrete dependent variables with multiple choices (Deressa et al., 2009; Legesse et al., 2013; Tessema et al., 2013). MNL was employed to estimate the effect of explanatory variables on the choice of adaptation options to climate change and variability. The model is normally estimated using the iterative maximum likelihood estimation procedure, which yields unbiased, efficient and consistent parameter estimates (Deressa et al., 2008, 2009). The formula is given as follows:

$$P(y = j / x) = \frac{\exp(x\beta_j)}{\left[1 + \sum_{h-1}^{j} \exp(x\beta_h),\ j = 1.., J\right]}$$

Where P stands for probability, J stands for adaptation options, X for explanatory variables and β_j = K x 1 is coefficients, j = 1, 2. . , J.

The equation of multinomial logistic regression model requires the independent irrelevant alternative assumption (IIA) as noted in Deressa et al. (2009). It indicates that the probability of using a certain adaptation options by a given household needs to be independent from the probability of choosing another adaptation option. Thus, before data analysis and presentation, the model has been tested for the validity of the IIA assumptions, using the Hausman test for IIA as explained in Hassan and Nhemachena (2008) and Deressa et al. (2009).

Dependent variables

The dependent variable for multinomial logit model used in this study is households' choice decision on climate change adaptation options used by the farmers. The alternative climate change adaptation strategies include crop diversification, changing planting date, changing crop varieties/crop types, soil and water conservation practice and irrigation practices. These are frequently reported climate change adaptation methods in rain-fed agriculture of many African countries (Hassan and Nhemachena, 2008; Deressa et al., 2009). Thus, the dependent variable in the model is a categorical variable taking a discrete value of 1, 2, 3, 4, 5 and 6 representing the above choices, where;

(1) Change in crop and variety: It involves switching to varieties better suited to the new climate such as the use of stress tolerant crops and/or varieties that have a shorter growing period. It also includes cultivating crops better suited to the new climate and growing conditions.

(2) Change in planting dates: It involves the adjustment of planting time better suit the shifts in the growing season by delaying or undertaking early planting/sowing.

(3) Soil and water conservation practices: Includes the adoption of soil and water conservation practices such as terracing, soil/stone

Table 2. Explanatory variables hypothesized to affect the choice of conservation practices.

Variables	Definition	Description	Expected sign
AgroE	Local agro-ecology (Kola)	Dummy, takes the value of 1 if *kola* and 0, otherwise.	±
SexHH	Sex of the household head	Dummy, takes the value of 1 if male and 0, otherwise	+
AgeHH	Age of the household head	Continuous	+
Education	Educational status of household heads	Continuous	+
Family size	Family size of the household	Continuous	±
Farm size	Land holding per family	Continuous	+
FINCOME	Farm income	Continuous	+
TTLU	Total livestock holding in TLU	Continuous	+
Extension	Access to extension service	Dummy, takes the value of 1 if yes and 0, otherwise	+
Credit	Access to credit service	Dummy, takes the value of 1 if yes and 0, otherwise	+
Climate info	Access to climate information	Dummy, takes the value of 1 if yes and 0, otherwise	+

banding, runoff diversion and mulching to improve soil fertility, prevent erosion and conserve soil moisture

(4) Crop diversification: this includes growing of different varieties of crops in the same field through intercropping, mixed cropping, multiple cropping such as dividing of lands for different types of crops to serve as an insurance against complete failure as various crops and varieties respond differently to climatic hazards.

(5) Irrigation: It involves the adoption of farmers to build water harvesting schemes such as traditional hand dug or shallow open wells for the abstraction of groundwater for irrigation, diversion and pumping of spring water to practice irrigation.

(6) No adaptation: It includes if farmers are not taking any of the climate change adaptation options mentioned above.

Independent variables

Independent variables are variables that determine whether or not a household recognizes climate change and take some mechanism used to adapt its impact. Based on the review of literature on adaptation studies, a range of household socioeconomic and demographic characteristics, institutional factors and agro-ecological settings that describe local conditions were hypothesized to influence farmers' adaptation choice in the study area. The expected effect of each of these variables is presented in Table 2.

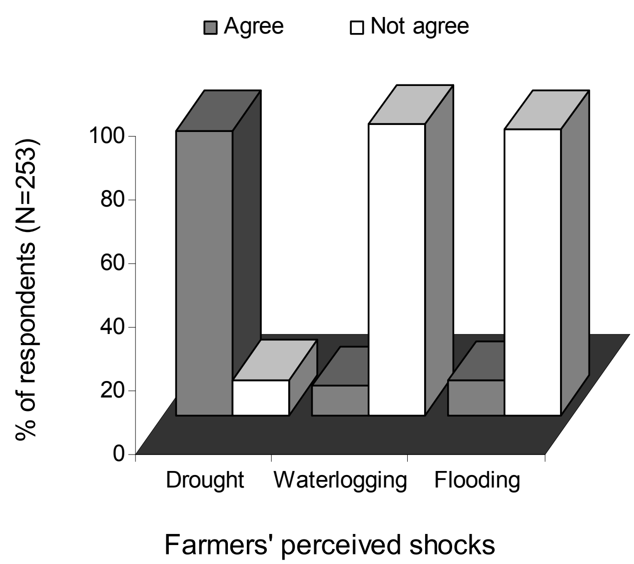

Figure 1. Farmers' perceived climate induced disasters in the study area.

RESULTS AND DISCUSSION

Farmers' perceived shocks

The surveyed households have encountered many environmental shocks such as drought, flooding and water-loggings (Figure 1). The result revealed that most of the contacted households had recognized drought as the major environmental hazard that they have encountered in their life. In line with this, Mengistu (2011) showed that drought was ranked as primary climate hazard by the community of *Adiha*, central Tigray, Ethiopia. Moreover, Deressa (2010) reviewed that between 1965 and 2009 Ethiopia has encountered drought about ten times. During these times, the region was affected by eight of the drought hazards; indicating how susceptible is the region to weather vagaries. Particularly, the 1984 drought (the worst in the modern history of Ethiopia that took one million lives) is still fresh to remember in many families.

These shocks have resulted in a variety of reported losses. Most of the respondents perceived that these shocks have reduced crop production that resulted to food insecurity (Table 3). In line with this, Teka et al. (2012) reported that there was a general perception among rural households that crop and livestock production, and land productivity declined in the last 20 years. Moreover, about 77.1 and 84.9% of the farmers perceived that the amount of water used for irrigation and for home and animal consumption has declined due to decline in rainfall amount, resulted from climate induced impacts. Farmers indicated that deep boreholes are open

Table 3. Perceived effects of climate induced shocks in the study area.

Climate induced disaster	Respondents	
	N=253	Percent*
Crop productivity decline	228	90.1
Shortage of water for irrigation	195	77.1
Shortage of water for home/animal consumption	215	84.9
Emergence/resurgence of new pests (weeds and insects)	185	73.1
Loss of landrace cultivars	189	74.7

*Percentage do not add up to 100 because of multiple responses.

for municipal water services. Thus, this effect might not be due to climate change alone but also due to pressurized underground water utilization. On the other hand, climate shocks such as recurrent drought associated with long dry spell and shortening in the length of growing period have resulted to loss of landrace cultivars (74.7%) and to face with new pests (73.1) including *striga* and *parthenium* weeds. In addition, farmers' also pointed out declined in crop productivity followed by a shortage of water for consumption and irrigation purposes as indicators of climate change.

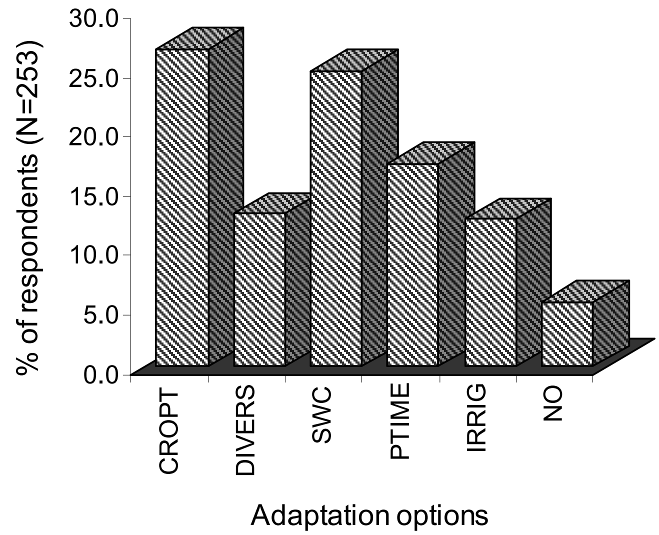

Figure 2. Farmers' adaptation strategies of the study area; CROPT: changing crop type/variety; DIVERS: crop diversification; SWC: soil and water conservation; PTIME: changing planting time; IRRIG: use of irrigation and NO is no adaptation.

Farmers' adaptation strategies

The surveyed farm households who claimed to have observed climate change in the last 20 to 30 years were asked if they have responded through adaptations to minimize the impact and/or to optimize opportunities of climate change. Accordingly, farmers used different management practices to reduce the effect of climate change. In this regard, farmers who perceived change in climate have used changing crop type/variety, soil and water conservation, changing in planting date, crop diversifications and irrigation practices as climate change adaptation options (Figure 2). On the other hand, despite their awareness on climate change, 5.5% of the farmers did not use any of the adaptation options indicated earlier. Similarly, Mengistu (2011) also reported that irrigation, changing crop types/varieties and soil and water conservation practice are commonly used climate change adaptation methods by the farming community of *Adiha*. The report further noted that, despite their importance, crop diversification and change in planting date were not common in these communities. A survey carried out in the Nile Basin of Ethiopia also revealed that farmers who claimed to perceive change in climate have used planting trees, soil conservation, use of different crop varieties, changing planting dates and irrigation to reduce the impact (Deressa et al., 2009). Moreover, Legesse et al. (2013) noted that crop diversification together with soil and water conservation and water harvesting practices were commonly used climate change adaptation strategies in eastern Ethiopia.

Adaptation strategies vary from region to region and/or from place to place depending both on the extent and range of climate change or the exposure of the area to climate change, and the socioeconomic background of the people in the area (Sahu and Mishra, 2013). In general, similar adaptation strategies have been reported in different areas (Nhemachena and Hassen, 2007; Fosu-Mensah et al., 2010) (Figure 2).

Determinants of adaptation options

The Multinomial Logit Model was run taking 'no adaptation' as the base category against which the remaining outcomes compared (Table 4). An important assumption of the MNL is the Independence of Irrelevant Alternatives (IIA) and the model was tested using the Hausman test to see if it fulfills the assumption. The Hausman test supported that the IIA is not violated with

Table 4. Parameter estimates of the multinomial logit climate change adaptation model.

Explanatory variables	Change in crop type/variety			Crop diversification			Soil and water conserve			Irrigation			Adjust planting date		
	Coef	P_{value}	ME	Coef	P_{value}	ME	Coef	P_{value}	ME	Coef	P_{value}	ME	Coef	P_{value}	ME
AgroE	20.24***	0.000	0.3716	-0.3177	0.826	0.1619	-3.83***	0.004	-0.5370	-4.59***	0.001	-0.2334	1.108	0.381	0.236
SexHH	1.028	0.490	0.0006	0.4655	0.729	0.1131	1.138	0.391	0.4633	2.031	0.193	0.1415	-2.77**	0.026	-0.718
Education	0.5803	0.229	-0.0000	0.7820	0.104	0.0169	0.6538	0.174	-0.0214	0.8172*	0.090	0.0141	0.6376	0.178	-0.009
AgeHH	0.2007**	0.010	9.7e-6	0.1979**	0.011	0.0020	.2116***	0.007	0.0127	0.2132***	0.008	0.0029	0.0805	0.268	-0.017
Family size	0.1801	0.658	-0.0001	0.5328	0.190	0.0415	0.2483	0.542	-0.0368	0.1391	0.739	-0.0207	0.4160	0.300	0.016
Farm size	0.9678	0.812	0.0003	-0.4486	0.913	-0.173	0.6773	0.868	0.1222	0.9812	0.811	0.0619	0.3761	0.926	-0.011
FINCOME	0.0008*	0.083	1.7e-7	0.0003	0.478	-0.000	0.0006	0.170	0.0000	0.0007	0.156	8.6e06	0.0007	0.133	0.000
TLU	0.6164	0.293	-0.0001	0.8368	0.155	0.0113	0.7689	0.189	-0.0049	0.8807	0.135	0.0117	0.6700	0.249	-0.017
Extension	2.477*	0.081	0.0007	0.6618	0.610	-0.073	1.323	0.299	0.1514	0.9368	0.498	-0.0077	0.6224	0.606	-0.070
Credit	1.061	0.488	0.0005	0.3880	0.787	0.0616	0.1645	0.907	0.0774	3.500*	0.055	0.2275	-1.55	0.249	-0.367
Climate info	1.136	0.420	-0.001	2.978**	0.033	0.0947	2.681**	0.043	0.1473	3.916**	0.025	0.1085	1.068	0.379	-0.347
Const	-38.8***	0.000		-16.8***	0.000		-15.6***	0.000		-21.2***	0.000		-7.30*	0.056	
Diagnosis															
Base category	No adaptation														
Number of observations	216														
LR chi-square (55)	297.69***														
Log likelihood	-218.78														
Pseudo R^2	0.405														

*, ** and *** indicates statistically significant at 10, 5 and 1%, respectively; ME: marginal effect; Coef: regression coefficient; AgroE: agro-ecology.

$\chi 2$ ranging from -31.02 up to 8.88 with probabilities almost equal to 1.0 (data not shown). Moreover, to make sure that the continuous explanatory variables do not create problem of multicollinearity, auxiliary regression was fitted and VIF was calculated. All the VIF values are less than 10 (1.03 up to 1.56), indicating that it is safe to assume the absence of multicollinearity. Likewise, contingency coefficient was calculated for the categorical variables to detect problem of strong association. The values of all coefficients were less than 0.75 (0.076 up to 0.545), indicating absence of strong relationship among the variables (data not shown). Therefore, all the hypothesized continuous and categorical explanatory variables were included in the model.

Model results

The estimated coefficients of the MNL model together with the levels of significance are portrayed in Table 3. The likelihood ratio statistics from the MNL model indicated that $\chi 2$ statistics (297.69) was highly significant ($P < 0.0001$), suggesting the model has a strong explanatory power. As noted earlier, the parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent variables: estimates do not represent the magnitude of change or its probability. Thus, the marginal effects from the MNL, which measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable, are also presented in Table 4. The result showed that the level of education of household head, age of the household head, farm income, extension service, credit service and climate information influence positively in using one or a combination of climate change adaptation strategies identified by farmers. In contrast, gender of the household head found to influence negatively the adoption strategies noted by farmers. Moreover, the agroecological settings where the farmers are living significantly affect the farmers' choice of climate change coping strategies. On the other hand, family size, farming size and the number of livestock ownership were not found to influence climate change adaptation options. The under mentioned section will discuss on variables that significantly influence climate change adaptation options.

Agroecological settings

Farmers living in different agroecological setting use different climate change adaptation methods. The multinomial logit model revealed that farming in *weynadega* decreases significantly the probability of using irrigation and soil and water conservation by 23.34 and 53.7%, respectively as compared to farming in *kola*. On the other hand, farming in *weynadega* increases significantly the probability of changing crop types and/or varieties by 37.16%, compared to the farmers living in the *kola* area. This difference might be arising due to the difference in soil, climate and other natural resources as well as experience to climate related stresses. The most important characteristic feature of lowland areas that limit crop production is high temperatures, which enhances evapotranspiration loss and create heat stress. Farmers living in this agroecological setup are, therefore, expected to invest management strategies that reduce heat loads while increase availability of moisture in the crop root zone. The positive concomitant between farming in the lowland and adoption of soil and water conservation and irrigation might be justified due to the aforementioned fact. In line with this, Deressa et al. (2009), Tesso et al. (2012) and Legesse et al. (2013) also observed that farmers living in different agroecological settings have different choice of adaptation to climate change impact. The report further revealed that farming in *kola* increases the probability of soil and water conservation and water harvesting practice as adaptation options, compared to *dega* or *weynadega.* On the other hand, farming in *kola* significantly reduces the probability of diversifying crop varieties, planting trees, and irrigation by 21, 13 and 2.3%, respectively, compared with farming in *weynadega* (Deressa et al., 2009).

Gender of the household head

Gender of the household head is one of the most important variables that significantly affect the farmers' choice of climate change adaptation options. As can be seen from Table 3, male headed households increase the likelihood to change crop types and/or varieties, to use crop diversification, to practice soil and water conservation and to use irrigation as climate change adaptation strategies. However, being male headed household reduces significantly the probability of using change in planting date by 71.8%. Overall, male-headed households have greater preferences for these strategies that require labor, finance and information than female-headed households, which relies on common practices known to most farmers, such as change in planting dates. This agrees with the argument that male headed households are more likely to get information about new technologies and take risky business than female headed households (Asfaw and Admassie, 2004). Similarly, Deressa et al. (2009), Legesse et al. (2013) and Mulatu (2013) concluded that being male-headed increases significantly the ability and choice of households' climate change coping strategies.

Age of the household head

Age of the household head, which is considered as a proxy indicator for farming experience, affects positively the farmers' climate change adaptation options. The result revealed that one year increase in the age of the household head significantly increases the probability of adopting change in crop type and/or variety, crop diversification, soil and water conservation and irrigation practices, respectively by <0.001, 1.1, 1.27 and 0.29%. This might be related to the fact that older farmers are able to assess the available technologies, gained enough knowledge and technical expertise on the options, which enable them to make adoption decision (Gbetibouo, 2009). Similarly, Deressa et al. (2009) reported that the probability of adopting change in crop varieties and tree planting was increased with age of the household head. On the other hand, age had no effect on adopting climate change adaptation options by farmers in eastern Hararghe, Ethiopia (Legesse et al., 2013; Tessema et al., 2013).

Education

Education of the household head increases the probability of adapting to climate change. Education significantly increases the use of irrigation practice as climate change adaptation methods. One year increase in the number of years of schooling was associated with a 1.41% increase in irrigation use. Moreover, all adaptation methods have a positive relationship with education. Farmers' with higher education are likely to have more information on climate change, which in turn might promote the probability of adopting climate change adaptation strategies. Furthermore, education is likely to enhance farmers' ability to receive, interpret and comprehend information relevant to making innovative decisions in their farms (Ndambiri et al., 2013). This result was similar to that of Deressa et al. (2009) and Tesso et al. (2012) while in contrast with that of Mulatu (2013), who noted a negative relationship between education and selection of climate change adaptation options. In the latter case, better educated farmers had left agriculture and the probability of using climate adaptation option was reduced.

Farm income

This variable had positive and significant influence in adopting climate change adaptation options. As farm income increases by one birr the probability of using change in crop type and/or variety as climate adaptation options increase by less than 0.001%. It is well known that adoption of new crop variety requires more financial resource than adoption to crop diversification and changing planting dates. The positive impact of farm income on climate change adaptation options could be associated to the fact that farmers with better financial capacity are more risk averse to crop production, have access to information and longer-time planning horizon (Deressa et al., 2008). Mulatu (2013) also showed that increase in farm income of the household increases the likelihood of adapting to climate change using soil conservation, irrigation and livestock production.

Extension services

As expected, extension visit to the households has positive influence on the probability of adopting the prevailing adaptation options. However, the effect of extension contact on adoption of climate adaptation option was significant only for changing in crop type and/or variety. Result of MNL model showed that a unit increase in extension contact is likely to increase the probability of the farmer to adopt change in crop type and/or variety by 0.07%. This result corroborates with that of Deressa et al. (2008, 2009), Tesso et al. (2012) and Mulatu (2013), where all noted that increase access to extension service has increased the probability of using climate change adaptation options in different parts of Ethiopia. Legesse et al. (2013) also reported a mixed effect, wherein increase in extension contact increase the probability of the household to adapt crop diversifications and the use of soil and water conservation strategy but decreases the probability of adopting water harvesting strategy. This might be due to the fact that water harvesting technologies are capital intensive investments and not necessary influenced by the farmers' awareness on the importance of the technology to adapt climate change impacts.

Credit service

Access to credit service also plays a positive role for farmers to adopt climate change adaptation options. The result revealed that increased access to credit is likely to increase the probability of the household to practice irrigation as climate change adaptation strategy by 22.75%. As already known, irrigation is one of the most effective climate change adaptation strategies; avoids crop failure due to moisture stress and enable farmers to cultivate year round. However, it also requires capital investment, which most of ordinary households could not afford. Therefore, leveraging the cash shortage of households through credit might encourage farmers' to engage in irrigation practices. Deressa et al. (2008, 2009) and Tesso et al. (2012) also noted that increase in credit access significantly enhanced the farmers' choice of climate change adaptation strategies. In contrast, Tessema et al. (2013) reported that credit access has negative influence of the probability of using tree planting as climate change adaptation option.

Climate information

Even though service on climate information delivery is not formal, access to information from different sources had positive influence on the probability of adaptation options to climate change. Access to climate information significantly increased the probability of using crop diversification, soil and water conservation and irrigation practices by 9.47, 14.73 and 10.85%, respectively (Table 3). This result implies the important role of increased institutional support in promoting the use of climate change adaptation options to reduce the negative impact of climate change. This result confirms the finding of Mulat (2013) who showed that increase in access to climate information increases farmers' likelihood to prefer crop diversification and change in planting date as climate change adaptation options. Moreover, Deressa et al. (2009) noted that information on temperature and rainfall has a significant and positive impact on the probability of using different crop varieties by 17.6%.

Conclusions

The results indicated that most of the farmers in the study region undertake soil and water conservation, crop diversification, change in crop type and/or variety, change in planting date and use irrigation practices as adaptation options to counteract the negative impact of climate change. On the other hand, gender of the household head, educational level of the household head, age of the household head, farm income, access to extension of crop and livestock production, access to credit service, access to climate information and agroecological setting of the area have significant impact on the choice of farmers to climate change adaptation options. Based on this result the following policy options are suggested:

(1) Investment in education and yield increasing technology packages that increases farm income in the

rural areas can be underlined as policy options to reduce the negative impacts of climate change.

(2) An effort that improves farmers' awareness on better production techniques, climate change and access to financial system (credit), which enhance capacity to adopt climate resilience adaptation options, is an important policy measure that should be considered.

(3) Future policy options need to fine-tune climate change adaptation technologies based on gender and agroecological settings

(4) Research and development has to focus on developing/adapting crop/livestock varieties resistant to drought and/or heat stress; as climate is expected to be hotter than today.

Conflict of Interest

The authors have not declared any conflict of interest.

ACKNOWLEDGMENTS

The authors are highly indebted to the Tigray Agricultural Research Institute (TARI) and the Ethiopian Institute of Agricultural Research (EIAR) for their financial support through the Rural Capacity Building Project (RCBP) to carry out this project. We also express our sincere thanks to the Ethiopian National Meteorological Agency for readily providing the daily rainfall and temperature data.

REFERENCES

Asfaw A, Admassie A (2004). The role of education on the adoption of chemical fertilizer under different socioeconomic environments in Ethiopia. Agric. Econ. 30:21 5-228.

Berhane G, Gebrehiwot A, Berhe K, Hoekstra D (2010). Commercialization of vegetable production in Alamata Woreda, Northern Ethiopia: Processes and Impact. IPMS, Ethiopia.

Conway D, Schipper ELF (2011). Adaptation to climate change in Africa: challenges and opportunities identified from Ethiopia. Glob. Environ. Change 21:227–237.

Deressa TT (2010). Factors Affecting the Choices of Coping Strategies for Climate Extremes. Environment and Production Technology Division. IFPRI Discussion Paper 01032

Deressa TT, Hassan RM, Alemu T, Yusuf M, 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 00798 September 2008.

Deressa TT, Hassan RM, Ringler C, Alemu T, Yusuf M (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. Glob. Environ. Change 19(2):248-255. doi:10.1016/j.gloenvcha.2009.01.002

Florence (2008). Land evaluation in Enderta district, Tigray, Ethiopia. MSc Thesis, Geomatics and Natural Resources Evaluation, università Degli Studi di Firenze. http://www.iao.florence.it/training/geomatics/Mekele/28_Ethiopia.pdf

Fosu-Mensah BY, Vlek PLG, Manschadi AM (2010). Farmers' perception and adaptation to climate change; A case study of Sekyedumase District in Ghana. World Food System - A contribution from Europe, Tropentag, September 14 - 16, 2010, Zurich.

Gbetibouo GA (2009). Understanding farmers' perceptions and adaptations to climate change and variability: The case of the Limpopo Basin, South Africa. IFPRI Discussion Paper 00849 February 2009.

Gebreegziabher Z, Stage J, Mekonnen A, Alemu A (2011). Climate change and the Ethiopian economy: A computable general equilibrium analysis. Environment for Development Discussion Paper Series P. 24.

Gebrehiwot HB (2005). The economic impact of HIV/aids on smallholder farmers of Alamata district, southern Tigray, Ethiopia. MSc Thesis, Haramaya University, Ethiopia.

Gebrehiwot T, van der Veen A (2013). Assessing the evidence of climate variability in the northern part of Ethiopia. J. Dev. Agric. Econ. 5(3):104-119.

Hadgu G, Tesfaye K, Mamo G, Kassa B (2013). Trend and variability of rainfall in Tigray, Northern Ethiopia: Analysis of meteorological data and farmers' perception. Acad. J. Agric. Res. 1(6):088-100.

Hassan R, Nhemachena C (2008). Determinants of African farmers' strategies for adapting to climate change: Multinomial choice analysis. Afr. J. Agric. Resourc. Econ. 2(1):83–104.

IPCC (2007). Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland P. 104.

Legesse B, Ayele Y, Bewket W (2013). Smallholder farmers' perceptions and adaptation to climate variability and climate change in Doba district, west Hararghe, Ethiopia. Asian J. Empir. Res. 3(3):251-265.

Mengistu DK (2011). Farmers' perception and knowledge of climate change and their coping strategies to the related hazards: Case study from Adiha, central Tigray, Ethiopia. Agric. Sci. 2(2):138-145.

Mulatu ND (2013). Determinants of farmers' preference for adaptation strategies to climate change: evidence from north shoa zone of Amhara region Ethiopia. MPRA (Munich Personal RePEc Archive) Paper No. 48753 posted 1. August 2013 11:07 UTC available at http://mpra.ub.uni-muenchen.de/48753/, Accessed on 10 Nov, 2013.

Ndambiri HK, Ritho CN, Mbogoh SG (2013). An evaluation of farmers' perceptions of and adaptation to the effects of climate change in Kenya. Int. J. Food Agric. Econ. 1(1):75-96.

Nhemachena C, Hassan R (2007). Micro-level analysis of farmers' adaptation to climate change in Southern Africa. IFPRI Discussion Paper 00714 August 2007.

Sahu NC, Mishra D (2013). Analysis of perception and adaptability strategies of the farmers to climate change in Odisha, India. APCBEE Procedia 5:123-127. Doi: 10.1016/j.apcbee.2013.05.022

Teka K, Van Rompaey A, Poesen J, Welday Y, Deckers J (2012). Impact of climate change on small-holder farming: A case of eastern Tigray, northern Ethiopia. Afr. Crop Sci. J. 20(2):337-347.

Tessema YA, Aweke CS, Endris GS (2013). Understanding the process of adaptation to climate change by small-holder farmers: the case of east Hararghe Zone, Ethiopia. Agric. Food Econ. 1:13.

Tesso G, Emana B, Ketema M (2012). Econometric analysis of local level perception, adaptation and coping strategies to climate change induced shocks in North Shewa, Ethiopia. Int. Res. J. Agric. Sci. Soil Sci. 2(8):347-363.

Vincent K, Cull T, Chanika D, Hamazakaza P, Joubert A, Macome E, Mutonhodza-Davies C (2013). Farmers' responses to climate variability and change in southern Africa – is it coping or adaptation? Climate Dev. 5(3):194-205.

You GJY, Ringler C (2010). Hydro-economic modeling of climate change impacts in Ethiopia. IFPRI Discussion Paper No. 00960 April 2010.