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Determinants of farmers choice of adaptation to climate variability in Dera woreda, south Gondar zone, Ethiopia

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Abstract

Background: Climate variability causes enormous suffering particularly on rural farmers' whose livelihoods depend largely on rain-fed agriculture. Ethiopia in general the Dera woreda in particular is not an exception in this regard. The main purpose of this study was to identify the determinant factors that influence the choice of farmers' adaptation strategies to climate variability from 110 households in Dera woreda, south Gondar zone, Ethiopia. Accordingly, descriptive statistics and Multi-Nominal Logit model (MNL) were employed to analyze the data on household and demographic characteristics and the determinant factors that influences the choice of farmers adaptation, respectively.

Results: The results showed that the major climatic related hazards in the study area were flooding (31.8 %), followed by hailstorm (19 %), drought (17.3 %), crop-pest (16.4 %) and livestock epidemic (15.5 %). In order to tackle the effects of climate variability, households in the area pursued crop diversification (38.2 %), soil and water conservation (31.8 %) and seasonal migration (19 %) as the most dominant and frequent adaptation measures. The MNL model also found that the adaptation measures taken by the households are influenced by some predictor variables such as gender of the household head, age, access to extension services, agro-ecological location, farm size, family size and perception on temperature.

Conclusion: In order to overcome the challenges that the farmers have been facing in employing various adaptation measures in response to climate variability, the government needs to support them in promoting the appropriate adaptation measures suitable in varied agro-ecological zones.

Keywords: Climate variability, Adaptation, Determinants, Multi-nominal logit model

Background

The effect of climate variability and change is more sever in the developing countries than the developed ones due to high vulnerability and least capacity to cope up to these changes (IPCC 2001; UNFCCC 2007) which is particularly true in the continent of Africa. Africa's high vulnerability to the impacts of climate change and variability is exacerbated by widespread poverty, recurrent droughts and floods, dependence on natural resources and biodiversity, over dependence on rain fed agriculture and conflicts that have engulfed the continent (Davidson et al. 2003 as cited in Nyong et al. 2007). Agriculture is the basis for the livelihoods of millions of people in Africa. An average of 70 % of the population lives by farming and 40 % of all exports are earned from agricultural products (IPCC 2001). In addition, 10–70 % of Gross Domestic Product (GDP) in Africa is generated by agriculture (Mendelssohn et al. Mendelsohn et al. 2000). According to reports of the IPCC (2007), the projected yield reduction due to climate change and variability in some poor countries could be as much as 50 % by 2020 (Boko 2007). This is particularly true in Ethiopia, where more than 85 % of its population is dependent on rain-fed agriculture. Since 1980 Ethiopia experienced at least five major

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droughts caused as a result of decline in rainfall which in turn led to the death of hundreds of thousands of people, which facilitated the country's dependence on food aid. Due to fluctuations in climate, however, Ethiopia became one of the largest receipts of food aid which reached about 20–30 % in the sub-Saharan Africa. Over the last 50 years, Ethiopia experienced both warm and cool years, though the warmest days showed an increment in recent years, particularly by 0.37 % in every ten years (Marye 2011).

Among the Ethiopian regions, however, the Amhara is one of the most vulnerable areas to climate variability and change. The increase temperature along with a decrease in precipitation, have becoming a serious problem in the region that frequently affected the agricultural sector. Crop-pest, livestock epidemic, hailstorm, drought, flood become the most dominant and frequently occurring climate related shocks in the region in general in *Dera woreda* in particular (Misganaw et al. 2014). In order to tackle or at least to minimize the effects of climate variability on their lives and livelihoods, farmers in the area have been pursuing various adaptation options. However, the choice of particular adaptation measures may be positively or negatively affected by specific variables such as household head's education, access to extension and credit services, climate information, agro-ecology,

household income, farming experience, household head age, family size, perception to climate variability, and gender of the household head (Shiferaw and Holden 1998; Belaineh et al. 2004; Nhemachena and Hassan 2007; Aster 2010; Deressa et al. 2009; Arjan et al. 2011; Declan and Lisa 2011; Woldeamlak and Dawit 2011; Gutu et al. 2012; Nabikolo et al. 2012; Badge et al. 2013; Yibekal et al. 2013; Belay 2014; Menberu and Yohannes 2014; Misganaw et al. 2014). However, research on the existing adaptation measures practiced by the farmers' and the determinant factors that affects farmers' choice of adaptation in *Dera Woreda* is very limited. Understanding the factors associated with adaptation would help policy makers for future intervention to address the challenges of sustainable development to climate variability. Thus, the main purpose of this study was to identify the determinant factors that affect farmers' choice of adaptation in *Dera woreda*.

Methodology

Sampling design

The study is carried out in *Dera* woreda, located in South *Gondar* Zone of the *Amhara* National Regional state of Ethiopia (Fig. 1). The study employed a combination of purposive and random sampling procedures to select the *Dera* woreda among the districts of the south Gondar
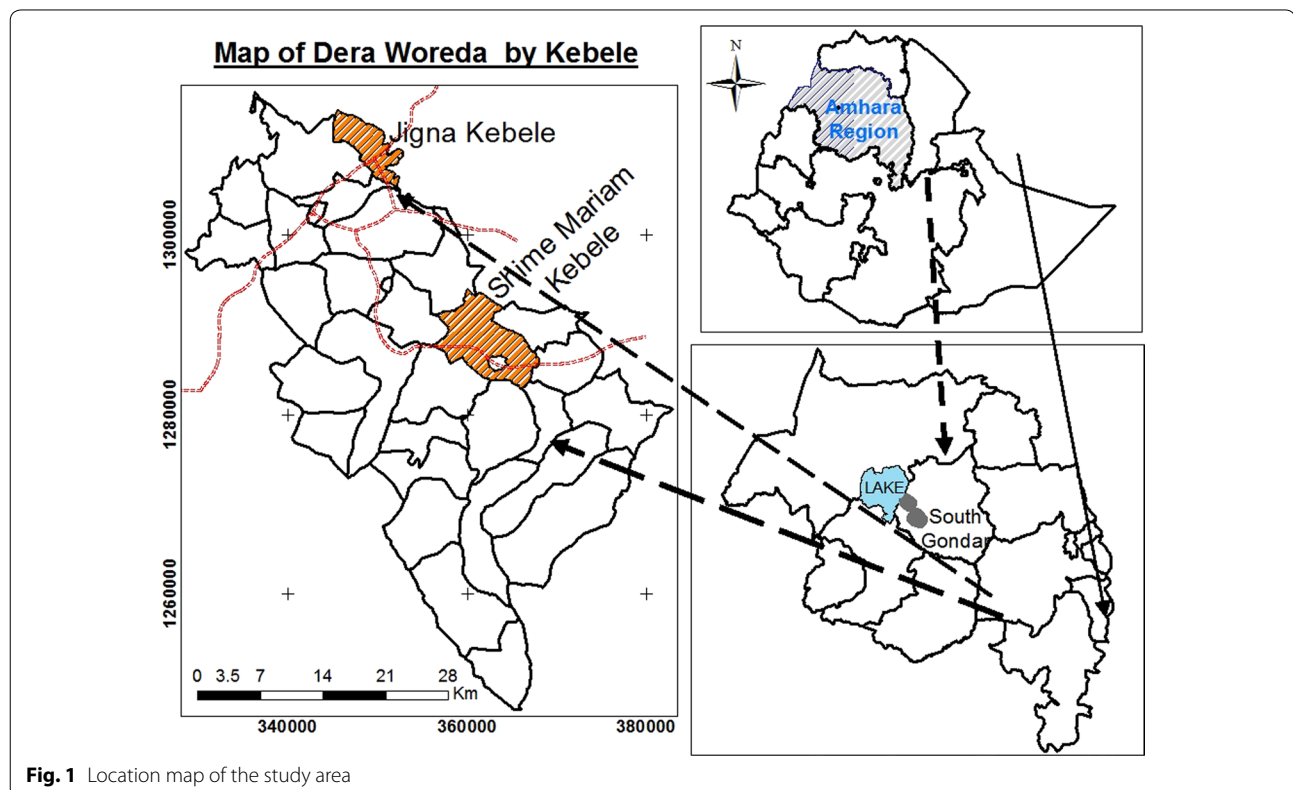

Fig. 1 Location map of the study area

zone and sample *kebeles* and households, respectively, during which the former was selected due to its vulnerability to climate variability. Consequently, two *kebeles* of the district were randomly selected from the woina dega (mid-land) and dega (highland) agro-ecological zones. Afterward, simple random sampling method was used in selecting households' from woina *dega and dega* in consideration with similar proportions. For this purpose, the formula of Cochran (1977) was used to determine the required sample size at 95 % confidence level, 5 % degree of variability and 7 % level of precision. Using this formula, 110 sample households were selected. However, in order to minimize the risk of non-response or recording error and to make the data more reliable, 5 % contingency was added to the sample size, making the sample size 116, though only 110 household heads were interviewed by which 6 of them have been dropped due to incomplete or inconsistent data.

The data were collected from both direct and indirect sources. Primary data were collected from key informants, focus group discussion and household survey. Different groups of participants with different socio-economic groups such as female and male headed households', the elderly and young people, vulnerable social groups including women and wealth groups (poor, middle and better off households'), extension workers, agriculture office workers and local authorities were interviewed. Secondary data were also collected from various government offices in the district, Central Statistical Authority (CSA), reports from agricultural office and published and un-published written sources.

After the data were collected, edited, coded and entered into SPSS 20, it was analyzed using descriptive statistical tools such as mean, percentages, frequencies and standard deviations. Descriptive statistics were used to analyze data on demographic, physical and socio-economic characteristics of households' in the area. Multinominal logit model was also employed to analyze the determinant factors that affect the choice of households' adaptation measures to climate variability. The model is widely used by different researchers (Belaineh et al. 2004; Nhemachena and Hassan 2007; Deressa et al. 2009; Fatuase and Ajibefun 2013; Yibekal et al. 2013; Menberu and Yohannes 2014). The Multinomial logit model is used in dealing with more than two outcomes of the dependent variable. In this study, therefore, the dependent variable, adaptation, has more than two outcomes such as crop-diversification, soil and water conservation and seasonal migration.

Results and discussions

The majority of female and male headed households' despite differences in sex, age, social roles and agro-ecology perceived climate variability in the study area manifested in terms of erratic rainfall and an increase in temperature for the last couple of years, months and decades. In response to this, the descriptive statistics found that (89.1 %) of households employed at least one adaptation strategy among others. Based on the importance of each strategy to their livelihood and agricultural activities, crop-diversification (38.2 %), soil- and water conservation (31.8 %) and seasonal migration (19.1 %) were identified as the major adaptation strategies both in the *dega* and *woina dega* agro-ecological zones of the study area.

The explanatory variables that are hypothesized to affect the dependent variable as indicated in Table 1 are agro-ecology, family size, farm size, access to extension service, age, sex of the household head, perception on temperature, farming experience, farmer to farmer extension, water access and climate information while the outcomes of the dependent variables are crop-diversification, soil and water conservation and seasonal migration.

The above explanatory variables were inserted into SPSS version 20 (see Table 2). It was found that the inclusion of all variables did not bring statistically significant relationships, hence some variables such as farming experience, farmer to farmer extension, water access and climate information were rejected in the analysis.

Multi-nominal model results

The MNL model was run taking "no adaptation" as a base category against other groups to be compared with. In order to see the probability of a particular choice of adaptation for a unit change in the independent variables, the regression coefficients, average marginal effect and their significance levels were used. The likelihood ratio statistics from the MNL model indicated that x^2 statistics was highly significant at $p < 0.001$, suggesting that the model has strong explanatory power.

As it is indicated in Table 3, agro ecology *woina dega* (mid land*)*, age of the household head, family size, farm size, access to extension services and perception to climate variability have significant and positive correlation with crop diversification and the use of SWC while age and farm size have negative but significant association with soil and water conservation and seasonal migration. Agro ecology *woina dega*(mid land*)*, sex of the household head and access to extension services showed positive and significant relation with seasonal migration. From this one can understand that the choice of a particular measure by a household might be significantly affected by some of the explanatory variables while the other measure might be affected insignificantly with different levels of significance. On the other hand, level of

Table 1 Variables hypothesized to affect adaptation decisions by farmers' in the study area

Variables	Description and measurement	Variable type
AEZWD	Takes the value of 0, if agro-ecology is W/Dega, 1 otherwise	Dummy
EDUC	Takes the value of 0 if cannot read and write and 1 otherwise	Dummy
FAMSIZE	Number of people in the household, measured in number	Continuous
SEX	Takes the value of 0 if male and 1 otherwise	Dummy
AGE	Age of household head in years	Continuous
FARMINC	Annual income in Birr from on farm activities	Continuous
FARMSIZE	Number of farm sizes owned by a household in hectares	Continuous
EXT-SERV	Takes the value of 0 if there is access and 1 otherwise	Dummy
CREDIT	Takes the value of 0 if there is access and 1 otherwise	Dummy
CLIMINFO	Takes the value of 0 if there is access and 1 otherwise	Dummy
FARMEXP	Farming experience of the household head	Continues
WATERAC	Takes the value of 0 if there is access and 1 otherwise	Continues
FAR-FARM	Takes the value of 0 if there is access and 1 otherwise	Continues
PERC-TE	Takes the value of 0 if there is access and 1 otherwise	Continues

education of a household head, farming experience, farm income, access to credit and climate information had no statistically significant effect on the selected adaptation measures.

Agro ecology *woina dega* (AEZW/D)

Farmers' living in different agro-ecological setting used different adaptation measures in response to climate variability. It has been reported that households' living in areas, where the amount of rainfall is less and high temperature than the average is more likely to employ different measures than households' receiving much rainfall and less temperature (Guto et al. 2012). This implies that rural households' living in the woina *dega* are more likely to adapt to the changing situations than those in *dega* due to the existence of high variability in climate compared with *dega* households'. The results of the MNL model, however, shows that farmers' living in *woina dega* are more likely to use crop-diversification and seasonal migration as the main strategy at $p < 0.05$ and $p < 0.01$ respectively relative to the reference category. Living in woina *dega* can increase the probability of using crop diversification and seasonal migration by 6 and 27 % times greater than those households' living in the *dega* respectively. This finding is supported by (Belaineh et al. 2004 and Deressa et al. 2008). The difference might be attributed to the difference in soil, climate and other natural resources as well as experiences to climate related stress.

Age of the household head (AGE)

The results of the MNL model shows that age of the household was found to be positively and significantly correlated with crop-diversification at $p < 0.05$. In this case, a one unit increase in the age of the household increases the probability of using crop diversification by 1.1 %. Older farmers' are more likely to involve in

Table 2 Mean comparisons (a one-way ANOVA) of explanatory variables

Farm and farm characteristics	Crop-diversif		SWC		Migration		No-adapt		*p* value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
AEZWD	0.33	0.47	0.40	0.49	0.24	0.43	0.83	0.38	0.086*
EDUC	0.19	0.39	0.46	0.50	0.33	0.48	0.25	0.45	0.000***
FAMSIZE	6.6	2.0	6.2	1.0	4.0	1.3	3.9	1.0	0.052*
SEX	0.21	0.41	0.03	0.16	0.05	0.218	0.17	0.38	0.000***
AGE	55	8.8	39	6.1	36	10	39	8.2	0.000***
FARMINC	1543	1168	2165	1612	516	604	426	522	0.000***
FARMSIZE	1.4	0.57	1.2	0.67	0.41	0.39	0.588	0.3	0.002***
EXT-SERV	0.31	0.46	0.63	0.49	0.43	0.50	0.83	0.38	0.181
CREDIT	0.31	0.46	0.54	0.50	0.48	0.51	0.33	0.49	0.507
CLIMINFO	0.52	0.50	0.60	0.49	0.71	0.46	0.67	0.49	0.000***
FARMEXP	35.2	10.4	24	12	21	14	16	8	0.066*
WATERAC	1.76	0.43	1.6	0.49	1.8	0.35	1.9	0.28	0.066*
FAR-FARM	0.12	0.32	0.06	0.23	0.10	0.30	0.08	0.28	0.832
PERC-TE	1.2	0.43	1.1	0.32	1.2	0.46	1.5	0.52	0.050*

Table 3 Parameter estimates of the multinomial logit (MNL) model for adaptation measures to

Crop-diversification				Soil and water conservation			Seasonal migration		
Variables	B	Sig.	Exp (B)	B	Sig.	Exp (B)	B	Sig.	Exp (B)
AEWD	4.242	0.035**	6.531	3.111	0.113	22.446	5.621	0.005***	276.06
AGE	0.162	0.035**	1.176	−0.280	0.006***	0.756	−0.022	0.0759	0.852
SEX	1.139	0.577	3.124	4.314	0.055*	0.76	5.996	0.015**	401.76
EDUC	1.391	0.516	4.020	0.786	0.681	2.196	1.300	0.485	0.096
FAMSI	0.818	0.081*	2.267	0.927	0.054*	2.526	0.109	0.810	1.115
FARIN	0.000	0.215	1.000	0.000	0.103	1.000	0.000	0.513	1.000
FARSI	4.366	0.059*	78.699	4.948	0.038**	14.89	−0.030	0.989	0.971
EXT	3.949	0.008***	51.870	2.624	0.063*	13.796	2.990	0.020**	19.88
CRE-S	1.655	0.268	5.233	−0.882	0.537	0.414	−0.018	0.989	1.982
PER-T	2.831	0.066*	16.963	2.640	0.067*	14.009	0.467	0.728	1.596
CONS	−22.423	0.000		−5.823	0.147		−7.480	0.052	

*, **, *** indicates levels of significance at 10, 5 and 1 % respectively, dependent variable-adaptation; reference category: no adaptation

crop-diversification than younger ones. The probable reason for the positive association is due to the fact that age may likely endow the farmers' with the requisite experience that will enable them make better assessment of the risks involved in climate change adaptation investment decisions. This argument is in line with Arega (2013) who noted households' who have long experience in farming can predict the trends of crop production better than young households' can. Most of the studies (Deressa et al. 2009; Misganaw et al. 2014) repeatedly argued that an increase in age does mean an increase in farming experience which would increase farmers' indigenous knowledge to respond to the hazards resulted in climate variability.

On the other hand, age of the household head shows negative correlation with soil and water conservation and seasonal migration at p < 1 and p < 10 % which means that a one unit increase in the age of the household decreases the probability of using soil and water conservation and seasonal migration by 0.7 and 0.8 times greater relative to the base category. This implies that older farmers' are less likely to take soil and water conservation and seasonal migration which require more labor. The probability of adapting soil and water conservation and seasonal migration decreases the older a farmer is. Thus, younger households' are active and energized than older households' in the application of soil and water conservation and seasonal migration as a strategy. This finding is in agreement with Madison (2006) who noted that older households' are less likely to use the two adaptation measures compared with younger ones.

Gender of the household head (SEX)
Gender of the household head is one of the most important variables that significantly affect the farmers' choice of climate variability adaptation options. In the prevalance of climate variability, sex of household head showed positive and significant correlation with soil and water conservation and seasonal migration at p < 10 and p < 5 %, respectively. Being male headed households' increase the probability of using soil and water conservation and seasonal migration as an adaptation strategy by 70 and 40 %, respectively relative to the reference category. This is because male headed households' have greater preferences to use soil and water conservation as a strategy that require labor, finance and climate information than female headed households'. This is in line with the argument that male headed households' are more likely to get information about new technologies and take risky business than female headed households' (Deressa et al. 2009). Abaje et al. (2013) noted that unlike men, women have limited access to information, land and other resources. On the other hand, seasonal migration as a strategy for female headed households' is less likely used compared with male-headed households'. This argument is in consistent with the study of (Agrawal 1997) asserted that in response to climate risks men are more likely to migrate and leave behind their families in search of secondary employment while women are more likely to stay home and face the situation.

Family size of the household (FAMSI)
As expected, the MNL model revealed that family size is positively and significantly correlated with the household

decision to pursue crop-diversification and soil and water conservation at p < 10 %. A one person increase in the family can increase the probability of using the two adaptation measures by 2.2 and 2.5 %, respectively. Those households' who have larger family have an opportunity of pursuing various adaptation options in the face of climate variability. Thus, its positive and significant sign clearly shows that the larger the family size, the higher probability to respond to reduce its effects. This argument is repeatedly raised in many literatures (Deressa et al. 2009; Fatuase and Ajibefun 2013; Menberu and Yohannes 2014) who argued that large family is associated with higher labor endowment which would enable a household to accomplish various agricultural tasks especially at peak seasons.

Farm size (FARSI)
As Table 3 illustrates farm size has appeared to be positively and significantly correlated with crop-diversification and soil and water conservation at p < 10 and p < 5 %, respectively relative to the base category. A unit increase in one hectare per household would increase the probability of using both crop diversification and soil and water conservation by 78 and 14 % greater than those households' whose farmland is small. Households' with larger farm sizes are more probably to diversify their crops especially under dry seasons and reduce the negative impacts of climatic variability. This argument is in line with Misganaw et al*. (*2014) who found the same result.

However, farm size is negatively associated with seasonal migration, which means that a one hectare increase in farm size lowers the probability of using seasonal migration as an adaptation strategy by 0.9 times. When farm size is smaller and smaller, households' opt to use seasonal migration as the major measures to reduce the effects of adverse conditions. Since most of the adaptation measures employed by the rural households' in the *woreda* are agricultural based, those who do not have land or have small plot, would not have any option rather than migrating to some other places where employment opportunities are available. This result is expected in the sense that the more households' have larger farms, the more they tend to work more intensively on their land instead of going for another alternative to adapt to climate change and variability.

Access to extension service (EXT)
Among the institutional factors, access to extension contact is one of those significant variables that affect the farmers' choice of adaptation. Results of the MNL models shows that extension contact has positive and significant correlation with the likelihood of choosing the three adaptation measure such as crop-diversification, soil and water conservation and seasonal migration at p < 0.01, p < 0.1 and p < 0.05 respectively. A one unit increase in the extension contact is likely to increase the probability of the farmer to adapt the three adaptation measures by 51, 13 and 19 %, respectively higher than those households' who do not access extension services. Farmers' who have access to extension services are more likely to be aware of climatic conditions. This result is in line with many researchers (Maddison 2007; Guto et al. 2012; Nhemachena and Hassan 2007) who noticed that farmers' who obtain information through extension workers are more likely informed about the climatic situation and the responses followed.

Perception on temperature (PER-T)
The results indicated that farmers' perception to climate variability is one of the explanatory variables that affect the choice of farmers' adaptation measures. Perception of households' to the increasing temperature was found to be positively and significantly correlated with the choice of crop-diversification and soil and water conservation at p < 10 %. This study found that farmers' who perceived a change in temperature are more likely to adapt to climate variability by 16 and 14 times greater compared to those who do not perceived a rise in temperature. This is probably because a rise in temperature in a district was more likely to affect farm production and therefore more likely to adapt to reduce its effects. This data is in line with the information collected through key informant interview and focus group discussion that farmers' who did not perceive climate variability did not adapt at all. This possibility is due to the fact that farmers' who perceive the variability in temperature are likely to grow different heat-tolerant crop varieties. Guetibou (2009) found the same result in that farmers' who are aware of changes in climatic conditions have higher chances of taking adaptive measures in response to the observed changes.

Conclusion
Despite differences in social and gender groups, the majority of rural households' in the study area showed a unified perception on climate variability about the changing temperature and rainfall. Thus, there are no significant differences in perceptions and varying insights among rural households' observing climate variability over the last decades. This might be attributed to an existence of climate related risks such as flooding, hailstorm, crop-pest, livestock epidemic and drought which were identified to be the most frequently occurring climate related risks chosen by the majority of the households' in the area.

Farmers' who could perceive fluctuations in climate pursued at least one measures of adaptation compared

with those households' who do not perceive variability of climate at all. Thus, crop-diversification, soil and water conservation and seasonal migration were the three most frequently used and important adaptation measures pursued by households' in the study area. However, the choice of adaptation measures chosen by rural households' has been influenced by some explanatory variables. The multinomial logit (MNL) model shows that out of 14 independent variables, 7 were found to be significant at p value less than 1, 5 and 10 %. Agro ecology *woina dega* (mid land), age of the household head, family size, farm size, access to extension services and perception to climate variability have significant and positive correlation with crop diversification and the use of SWC practices while age and farm size have significant and negative association with SWC and seasonal migration. Similarly, sex of the household head, agro ecology *woina dega* (mid land), age of the household head, family size, farm size, access to extension services and perception to climate variability are significantly and positively associated with soil and water conservation and agro ecology *woina dega* (mid land), sex of the household head and access to extension services shows positive and significant relation with seasonal migration. Thus, policy formulation on sustainable development should consider the interests of rural households including women. Among others, government policies and strategies should be directed towards fulfilling credit access with low interest rates, provision of adequate extension services with knowledgeable and skilled extension agents who could give climate information on the right time including accessible areas and increasing extension-farmer ratio. Besides, women should be given due emphasis since they are the most vulnerable social groups due to lack of access and control over resources, socio-cultural barriers to plow and access climate information. In general, interventions that enhance income, access to finance, access to farm inputs, access to market should be an integral part of climate change adaptation policies and strategies.

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