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SMALLHOLDER FARMERS' PERCEPTIONS AND ADAPTATION TO CLIMATE VARIABILITY AND CLIMATE CHANGE IN *DOBA DISTRICT*, WEST HARARGHE, ETHIOPIA

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ABSTRACT

This study assessed farmers' perceptions and adaptation to climate variability and change in Doba District, West Hararghe, Ethiopia. The study also investigated determinant factors influencing adaptation strategies to climate variability and change. The study followed a multistage stratified random sampling procedure. Data collected from 160 sample households was used in this study. Descriptive statistics were employed to assess perceptions among gender and social groups while the multinomial logit model (MNL) was used to identify factors influencing adaptation strategies used by sample households to climate variability and change. The study finds that there are nearly unified perceptions of climate variability and change among gender and social groups. The adaptation strategies used in MNL model were crop diversification and the use of soil and water conservation practices, integrated crop and livestock diversification, engaging in off-farm income activities and rainwater harvesting. It is understood that agro-ecological locations, sex, family size, plot size, off-farm income, livestock holding (TLU), frequency of extension contact and training are the determinant factors influencing adaptation strategies.

Keywords: Climate Variability and Change, Perceptions, Adaptation Strategies, Multinomial logit model, Ethiopia

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INTRODUCTION

The climate has changed, is changing, and will continue to change regardless of what investments in mitigation are made (Joel and Anne, 1998). Climate impacts are being felt today and greater impacts are unavoidable tomorrow. In Ethiopia, the temperature has been increasing annually at the rate of 0.2°C over the past five decades. This has already led to a decline in agricultural production. Cereal production in Ethiopia is expected to decline still (by 12%) under moderate global warming (Yohannes and Mebratu, 2009). Mitigation efforts to reduce the sources of or to enhance the sinks of green house gas (GHG) will take time and requires international cooperation. Adaptation, in contrast, can reduce climate-related risks in human-managed systems on regional and local scales, and often with a short lead time. However, its scope is generally limited to specific systems and risk types (Fussel and Klein, 2004). Mitigation tackles the cause of climate change while adaptation tackles the effect of the phenomenon (MERET, 2009). Therefore, adaptation is critical in developing countries (Hassan and Nhemachena, 2008). Among the Ethiopian regional states, Oromia is already vulnerable to extremes of climatic variability; and climate change is likely to increase the frequency and magnitude of some natural disasters and extreme weather events. These extreme events could be worsened by existing social and economic challenges in the region, particularly for those areas and communities dependent on resources that are sensitive to climate changes (ONRS, 2010).

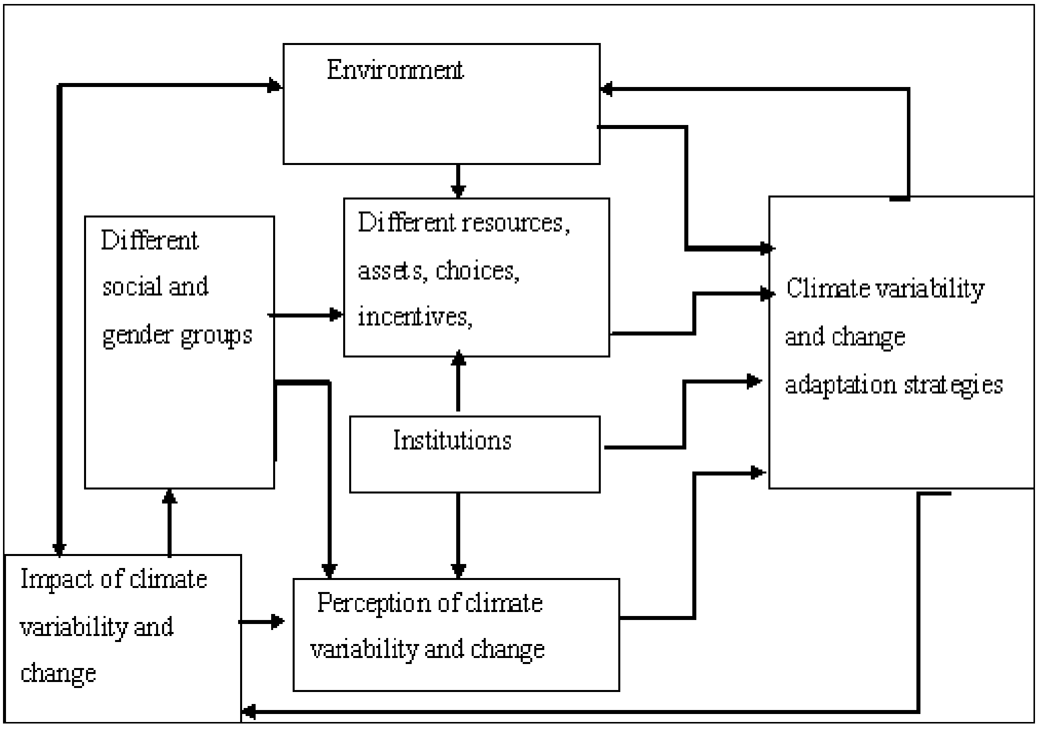
Doba is one of the most vulnerable *Districts* in Oromia region to climate variability and change. Climate variability and change poses a huge threat to farmers in the *District* due to their overwhelming reliance on small-scale agriculture. Land degradation and water shortages have become looming problems. According to information obtained from DWAO (2011) in *Doba District* agricultural production is frequently affected by climate related shocks. Climate variability also contributes to the occurrence of pest and insect infestations. Farmers in *Doba District* have been responding to climate variability and change through various strategies. But, there was no empirical data that substantiates or supports the existing adaptation strategies practiced by the farmers in research area. The information obtained in various literatures was insufficient and general, but adaptation strategies vary contextually and spatially (within communities and even within individuals). In fact, the available few literatures on climate change adaptation strategies were conducted using regional data, not specific to household-level. Furthermore, the literature on climate change has paid little attention to the analysis of factors influencing adaptation strategies chosen by smallholder households to adapt to climate variability and change and constraints associated with the choice of the adaptation measures. Thus, these are the gaps of knowledge that this study intends to bridge.

Understanding perceptions and adaptation strategies of individual households or communities in certain area does not only provide better location specific insights but also helps generate additional information relevant to policy and interventions to address the challenge of sustainable development in light of variable and uncertain environments. Therefore, an attempt was made in this study to identify perception and other socio economic factors influencing adaptation strategies pursued by farmers in response to climate variability and change. This study also assessed different gender and social differences in perception to climate variability and change and identifies the adaptation strategies used by the farmers in response to the risk associated with climatic variability and change in the study area.

OBJECTIVES OF THE STUDY

The overall objective of this study is to identify perceptions and adaptation strategies used by farmers' to climate variability and climate change. The specific objectives are: (i) to assess a difference among gender and social groups in perceptions to climate variability and climate change at household levels, (ii) to identify the determinant factors that influence adaptation strategies used by farmers in the study area, and (iii) to identify the existing adaptation strategies used by farmers in response to climate variability and change in the study area.

Figure-1. Conceptual Framework



Research Questions

The study attempted to address the following questions: (i) Is there a difference among gender and social groups in the research area in perception about climate variability and change? (ii) What are the determinant factors that influence adaptation strategies pursued by farmers in response to climate variability and change? and (iii) What kind of adaptation strategies are used by farmers in the study area in response to climate variability and change?

Conceptual Framework

The conceptual framework used in the present study portrays links between factors that affect the adaptation strategy of farmers to climate variability and climate change. Figure-1 portrays the conceptual framework that has been constructed based on the assumption that there are various driving forces behind farm households' decisions to choose adaptation strategies to climate variability and change. Some of the influencing factors that lead to adaptation strategies are differentiations in gender and social groups, different resources, assets, institution, environment and perceptions.

METHODOLOGY

Sampling Design

The study followed a multi-stage stratified random sampling procedure where a combination of purposive and random sampling procedures were used to select sample Kebeles[4] and households, respectively. At the first stage, out of 14 *Districts* in west Hararghe zone, *Doba District* was purposively selected due to the fact that the *District* is frequently susceptible to climate related problems. In the second stage, 6 *Kebeles* were selected from the 3 agro-ecologies, using probability proportional to size. At the third stage, in order to know perceptions to climate variability and change between gender groups' households in the selected kebeles were categorized in to male and female headed households. Then, sample households were selected using simple random sampling (SRS) with probability proportional to size technique. Simplified formula provided by Yamane (Yilma, 2005) is used to determine the required sample size at 95% confidence level, 5% degree of variability and 8% level of precision. Accordingly, 160 sample households were selected for inclusion in the analysis.

The Data

The data used for the present study were collected in February, 2012. Two types of data were used in this study, primary and secondary data. The primary data were collected from the households by using structured questionnaire survey and focus group discussions (FGDs) while secondary data were collected by reviewing documents of the various offices in Doba district.

Methods of Data Analysis

Both descriptive statistics and econometric model were used based on their importance for analyzing the quantitative data that have been collected from primary and secondary sources.

[4] Kebele refers to the lower administrative unit in a district.

Descriptive Statistics

Descriptive statistical tools such as, mean, percentages, frequencies and standard deviations were used to summarize and categorize the information gathered. Crosstabs, F-test, chi-square test and a one-way ANOVA tests were employed to compare group means.

Econometric Model

This study employed a multinomial logit (MNL) model to analyze factors influencing adaptation strategies used by farmers to climate variability and climate change in the study area. Because multinomial estimation is appropriate as it exhibits superior ability to predict discrete choices (Mohammed, 2007; Sosina et al. 2009) and because of the computational draw backs of multinomial probit (MNP). To describe the MNL model, let y denote a random variable taking on the values {1,2….j} for choices j, a positive integer, and let ***x*** denote a set of conditioning variables. In this case, y representing the adaptation measure chosen by any farming household in the study area. We assume that each farmer faces a set of discrete, mutually exclusive choices of adaptation measures (that means that a person chooses exactly one of the options, not more and not less) and these measures are assumed to depend on factors of x. Therefore, x represents a number of climate attributes, environmental, socioeconomic characteristics of households and other factors. The question is how, *ceteris paribus*, changes in the elements of ***x*** affect the response probabilities p(y=j/x), j = 1, 2…. J. Since the probabilities must sum to unity, p (y=j/x) is determined once we know the probabilities for j = 2…j. Let ***x*** be a 1x K vector with first element unity. The MNL model has response probabilities:

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

Where β_j is K × 1, j = 1……., J

Unbiased and consistent parameter estimates of the MNL model in equation-1 require the assumption of Independence of Irrelevant Alternatives (IIA) to hold. More specifically, the IIA assumption requires that the probability of using a certain adaptation method by a given household needs to be independent from the probability of choosing another adaptation method (that is, P_j/P_k is independent of the remaining probabilities). The parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent variable, but estimates do not represent either the actual magnitude of change nor probabilities (Greene, 2000). To interpret the effects of explanatory variables on the probabilities, marginal effects are hence computed. Differentiating equation-1 partially with respect to the explanatory variables provides marginal effects of the explanatory variables given as:

$$\frac{\partial p_j}{\partial x_k} = P_j\left(\beta_{jk} - \sum_{j=1}^{j-1} P_j \beta_{jk}\right) \qquad (2)$$

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

Variables Included in the Analysis

The dependent variables in the empirical estimation are adaptation strategies that are chosen by the sample households. The choice of adaptation strategies are based on the actions the sample households take to counteract the negative impact of climate variability and climate change.

Table-1. Variables hypothesized to affect adaptation decisions by farmers in the Study area

Variable label	Description and measurement	Variable type	Expected sign
AEZWD	1, if location (agro-ecology zone) is Woina Dega[5], 0 otherwise	Dummy	+
AEZKOLA	1, if location (agro-ecology zone) is Kola[6]	Dummy	+
AGE	Age of household head in years	Continuous	+
SEX	1, if the household head is male; 0, otherwise	Dummy	+
FAMSIZE	Number of people in the household, measured in number	Discrete	+
EDU	1, if the household head is literate 0, otherwise	Dummy	+
PLOTOWN	Number of farm plots owed by the household	Discrete	+
PLOTSIZE	Size of cultivated land in hectares	Continuous	+
FAREXP	Farming experience of the household head	Continuous	+
CROPFAIL	1, if the household had experienced crop failure	Dummy	+/-
INVEST	Amount of money invested for conservation	Continuous	+
OFFARM	Annual income in Birr[7] from off/non-farm activities	Continuous	+
ONFARM	Annual income in Birr from on farm activities	Continuous	+
TLU	Livestock holding in TLU	Continuous	+
FREXT	Frequency of annual extension contact	Discrete	+
TRAINING	1, if household head did participate in training, 0 otherwise	Dummy	+
CREDIT	Amount of credit received annually in Birr	Continuous	+
CLIMINFO	1, if HHH has access to climate information; 0 otherwise,	Dummy	+

These are: (1) Crop diversification strategies and the use of soil and water conservation (SWC) practices, (2) Integrated crop-livestock based diversification strategies, (3) Engagement in off-farm income activities, and (4) Rainwater harvesting. The independent variables of the study were those variables (households' characteristic and demographic, environmental, institutional and economic factors) which are hypothesized to have associations with the households' adaptation strategies. Based on theory, empirical literature, and researchers' knowledge of the contextual setting, 18 explanatory variables were identified and used. The potential explanatory variables which are hypothesized to influence farmers' adaptation strategies to climate variability and change in the

[5] Woina Dega is a local expression that is used to mean mid altitude areas.

[6] Kola is a local expression that stands for lowland areas.

[7] Birr is a local currency (1$ equals 18 Birr)

study area are summarized and presented in Table-1. Following the procedures proposed by, Variance Inflation Factor (VIF) and Contingency Coefficient (CC) were employed to detect multicollinearity for continuous explanatory variables and discrete variables, respectively. Breusch-Pagan test (hettest of STATA) was conducted to assess the presence of heteroscedasticity in the model.

EMPIRICAL RESULTS

Descriptive Statistics

Results showed that 99.4% of the respondents perceived increases in temperature while 96.9% perceived decrease in precipitation over the years. On the other hand 100% of sample households' perceived that rainfall has become more unreliable. In line with this, 95% of sample households perceived increases in frequency of occurrence of drought. The implication is that all social groups in the study area perceived that there are changes in the climate. This has emanated from existence of widespread covariate risks in the area as a direct result of climate variability and change. One of the possible explanations is that a shift from idiosyncratic risk to covariate risk due to climate change might have led to a unified local perception instead of multiple perceptions and varying insights among rural households.

Table-1. Gendered differences in perceptions of climate variability and change of sample households, (3-point Likert- type scale measure).

Perceptible variables	Male headed households			Female headed households			Pearson X^2 value
	Increasing	No change	Decreasing	Increasing	No change	Decreasing	
Temperature	99.3%	0.7%	0	100%		0	.697
Unreliability of rainfall	100%	0	0	100%	0	0	NC
Precipitation	0	2.2%	97.8%	0	9.5%	90.5%	.071***
Drought	94.2%	5.8%	0	100%	0	0	.259

Note: All values in the perceptions are proportion. *** represents significance at 10% probability level. NC: stands for not computed since the variable is a constant. Source: Computed based on survey data, 2012

Outcomes of the FGDs are also in agreement with the results obtained from the survey data. With a view to answer one of the questions put forth regarding gendered differences in perceptions, crosstabs statistics and measures of association were computed for the two way tables. Results are presented in Tables-2 and 3. Results revealed that perceptions are nearly unified among gender and social groups, except for a single variable. The Pearson chi-square test has shown that the two groups differ significantly (P < 10%) with respect to their perceptions on the trends of the amount of rainfall received in the area over the last 10 years.

Table-3. Gendered differences in perceptions of climate variability and change of sample households (yes or no type questions)

Indicators	Male headed households		Female headed households		Pearson X^2 value
	1= Yes	0 = No	1= Yes	0 = No	
Notice climate variability and change	100%	0	100%	0	NC
Have you ever faced crop failure during the last ten years	63.3%	36.7%	71.4%	28.8%	.45
Have you ever experienced major hazards related to climate variability and change over the last ten years	100%	0	100%	0	NC

Note: NC stands for not computed since the variable is a constant. Source: Computed based on survey data, 2012.

Descriptive statistics results have shown that farmers in *Doba District* have adapted to the effect of climate variability and change through a number of mechanisms. Particularly, sample households in the study area have multiple strategies for adapting to the impacts of climate variability and change. In addition to adaptation strategies related to agriculture, households do also engage in off-farm activities to complement their household income and food in case of adverse conditions in agriculture. Majority of sample households reported that they have used more than one type of adaptation strategies. This decision implies that a single strategy is inadequate in adapting to the impact of climate variability and change as combination of several strategies is likely to be more effective than a single strategy. In sum, it is learnt that rural households pursue crop-based (38.1%), livestock-based (27.5%), income-based (23.8%) and rain water harvesting (10.6%) strategies with a view to sustain livelihoods in the face of dynamic and ever changing external environment.

Farmers' in *Doba District* are facing various barriers that can make the adaptation strategies ineffective at the local level. The sample households listed a number of interrelated barriers associated with adaptation strategies that can make their lives very difficult in the presence of unreliable rainfall and other climate related hazards. These were limited financial capital (43.8%), limited credit availability (16.9%) and limited skills to engage in new income sources (22.5%). Lack of high yielding and drought resistant crop varieties (15%) were also mentioned as serious barriers to effective adaptation. A few sample households (1.9%) did report limited access to market as a barrier to effective adaptation. Finally, an attempt is made to check whether or not households pursuing different strategies are importantly and significantly different in terms of various farm and famer characteristics. To this end, a one way analysis of variance (ANOVA) is performed with a view to compare four means of the independent samples. A one way ANOVA tests whether or not the means of all groups are equal for different levels of one factor. Table-5 presents summary statistics for households surveyed.

Table-5. Mean comparisons (a one-way ANOVA) of farm and farmer characteristics of sample households

Farm and farm characteristics	Strategy 1 (n=61)		Strategy 2 (n=44)		Strategy 3 (n=38)		Strategy 4 (n=17)		Total (N=160)		F-value	Pro>F
	Mean	SD	Mean	SD	Mean	SD	mean	SD	Mean	SD		
Location dummy 1 (1= *Woina Dega*, else 0)	.6	.50	.3	.46	.34	.48	.47	.51	.43	.5	2.31	0.13
Location dummy 2 (1= *Kola*, else 0)	.3	.48	.5	.5	.26	.45	.35	.49	.37	.5	0.24	0.63
Age (years)	45.1	13.4	39.25	10.7	37.68	11.10	38.24	8.9	41	12.1	1.7	0.38
Sex (1= male, else 0)	.9	.30	.82	.39	.82	.39	1	.0	.87	.34	0.01	0.92
Family size	5.8	2.43	6.27	2.34	5.55	2.10	5.9	1.9	5.9	2.3	0.7	0.77
Education (1= literate, else 0)	.4	.5	.6	.5	.5	.5	.5	.5	.5	.5	1.5	0.23
Number of plots (number)	1.5	.6	1.7	.7	1.2	.5	1.5	.5	1.5	.6	1.4	0.25
Plots size (hectare)	.5	.2	.51	.19	.27	.2	.43	.13	.43	.2	2.5	0.02**
Farming experience (years)	24.3	13.4	18.2	9.76	17.2	8.5	17.5	7.4	20.2	11	1.5	0.06***
Crop failure experience (1=yes, else 0)	.61	.5	.66	.48	.6	.5	.76	.44	.64	.5	0.9	0.34
Investment on plots (Birr)	642	528	814	481	484	441	570.3	401	644	494	0.9	0.66
Off-farm income (Birr)	688	627	698	756	1541	924	518	595	837	834	1.8	0.08***
farm income (Birr)	1548	1306	3010	1952	740	1262	1453	855	1748	1681	1.4	0.08***
Tropical Livestock Unit	1.36	1.3	2.8	1.2	1.5	1.2	1.9	1.7	1.9	1.4	1.1	0.40
Frequency of extension contact	7.21	5.9	7.39	5.1	1.8	2	5.5	4.3	5.8	5.3	2.5	0.002*
Participation in training (1=yes, else 0)	.51	.5	.68	.47	.65	.5	.7	.5	.59	.5	1.4	0.24
Credit (Birr)	598.1	862.7	817.1	1067	460.5	795.8	564.7	734.8	662.1	898.7	10.4	0.42
Access to climate information (1= yes, else 0)	.36	.5	.4	.5	.2	.41	.2	.4	.3	.5	2.5	0.12

Note: *, **, and *** signify levels of significance at 1%, 5% and 10%, respectively. Source: own computation based on survey result, 2012.

Strategy 1 = Crop diversification strategies and the use of SWC practices (growing multiple crops such as maize, sorghum, Khat, coffee, using drought resistance crops and short duration crops like sweet potato and haricot bean); Strategy 2 = Integrated crop-livestock based diversification strategies (livestock diversification, livestock reduction through sale, livestock splitting at the time of severe shortage of fodder, changing livestock species composition in favor of browsers, grow fodder crops on SWC structure, purchasing supplementary animal fodder); Strategy 3 = Engagement in off-farm income source activities (sale of labor, involvement in productive safety net programs (PSNP), involvement in petty trade and pottery); Strategy 4 = Rainwater harvesting. F-tests are used to judge whether or not there are statistically significant difference among the four categorical outcome variables in terms of the explanatory variables included in the analysis. A one-way ANOVA test (Table-5) mirrors that there are statistically significant differences between some of the factors associated with major adaptation strategies used by sample households. The findings indicate that there are statistically significant differences ($P < 10\%$) among the four outcome variables with respect to plot size, farming experience, off-farm income and on-farm income. In addition, the F-test result reveals that there is a statistically significant difference among the categorical outcomes in terms of the frequency of extension services at 1% level of significance.

ECONOMETRIC RESULTS

The multinomial logit (MNL) model of sample households' adaptation strategies is estimated, in which households choose from a number of mutually exclusive adaptation strategies pursued in their contextual settings. Regression coefficients, average marginal effect and their significance levels from the MNL model are presented in Table-6. Results of the multinomial logit (MNL) model indicated that different socio economic, environmental and institutional factors affect the probability of selecting mutually exclusive adaptation strategies to climate variability and change. Accordingly, results presented in Table-6 show that agro ecology zone *Woina Dega* (mid land*)*, agro ecology zone *kola* (low land*)*, sex of household head, plot size and frequency of extension contacts have significant and positive influence on crop diversification and the use of SWC practices while family size, off-farm income and training have significant negative influence. On the other hand, plot size, livestock (TLU) and frequency of extension contacts are significantly and positively associated with integrated crop-livestock based diversification while family size, off-farm income and training are significantly and negatively associated. Similarly, agro ecology *Woina Dega* (mid land), agro ecology *kola* (low land), plot size and frequency of extension contact are significantly and positively associated with using rainwater harvesting whereas off-farm income has a significant negative impact. Some of explanatory variables are highly significant to affect the decision for a particular strategy and may be insignificant for the other strategy groups. Thus, the multinomial logit analysis results revealed that the decision of each class of climate variability and change adaptation strategy is influenced by different factors and at different levels of significance by the same factor. On the other hand, the multinomial logistic regression analysis applied to identify the determinants of adaptation strategies to climate variability and change showed that the explanatory variables: age, education, farming experience, number of farm plot owned, crop failure, amount invested, on-farm income, credit amount received and climate information had no statistically significant effect on adaptation strategies.

Table-6. Parameter estimates of the multinomial logit (MNL) model for adaptation strategies to climate variability and change

Variables	Crop diversification and the use of SWC practices				Integrated crop-livestock based diversification				Rainwater harvesting			
	Coef.	Std.err.	P value	Marginal effect	Coef.	Std.err.	P value	Marginal effect	Coef.	Std.err.	P value	Marginal effect
AEZWD	2.934	1.751	0.094***	.469	.319	1.875	0.865	-.502	3.605	1.888	0.056***	.038
AEZKOLA	4.418	1.85	0.017**	.278	3.018	1.865	0.106	-.279	4.463	1.935	0.021**	.012
AGE	.139	.089	0.122	.002	.134	.091	0.141	-.001	.109	.109	0.321	-.001
SEX	2.625	1.362	0.054**	.263	1.007	1.405	0.474	-.426	18.137	1897.4	0.992	.174
FAMSIZE	-.565	.266	0.034**	-.009	-.543	.277	0.050**	.002	-.299	.302	0.324	.006
EDU	-1.50	1.182	0.204	-.127	-.949	1.218	0.436	.117	-1.054	1.235	0.393	.006
PLOTOWN	.956	1.184	0.419	-.026	1.141	1.189	0.337	.048	.260	1.258	0.836	-.018
PLOTSIZE	10.114	4.596	0.028**	.425	8.189	4.651	0.078***	-.418	10.180	4.749	0.032**	.018
FARMEXP	.077	.095	0.416	.016	.004	.103	0.966	-.016	.034	.119	0.774	-.000
CROPFAIL	-.283	1.413	0.842	.168	-1.121	1.476	0.447	-.199	.818	1.560	0.600	.030
INVEST	.001	.001	0.477	.000	.001	.001	0.551	-9.96e-06	.0001	.001	0.959	-.000
OFFARM	-.003	.001	0.000*	-.000	-.003	.001	0.003*	.0001	-.003	.001	0.001*	-9.11e-06
ONFARM	-.001	.001	0.142	-.000	-2.91e-06	.001	0.995	.001	-.001	.001	0.139	-8.62e-06
TLU	.022	.441	0.960	-.196	.912	.458	0.046**	.193	.457	.462	0.323	.003
FREXT	1.177	357	0.001*	.010	1.152	357	0.001*	-.003	.996	.359	0.005*	-.004
TRAINING	-2.70	1.298	0.037**	.044	-2.977	1.366	0.029**	-.069	-2.061	1.358	0.129	.017
CREDIT	.0001	.001	0.805	-.000	.001	.001	0.363	.000	-.0004	.001	0.945	-8.35e-06
CLINFO	-1.476	1.124	0.189	-.077	-1.120	1.226	0.368	.079	-1.673	1.251	0.181	-.008
Constant	-9.945	4.018	0.013		-8.615	4.093	0.035		-.25.594	1897.405	0.989	

Note: *, **, and *** signify levels of significance at 1%, 5% and 10%, respectively.

Dependent Variable: Adaptation strategies; Number of observations = 160; LR Chi square (54) = 209.13; Pseudo R_ square = 0.5018; Log Likelihood = -103.80216; Prob. > Chi square = 0.0000; Base category: engagement in off-farm income activities

Agro Ecology *Woina Dega* (AEZWD)

Results of the MNL regression analysis have mirrored that making a living and operating in *Woina Dega* (mid land) appears to increase the likelihood of selecting and using adaptation strategies 1 and 4 (P < 10%), that is crop diversification and the use of SWC practices and rainwater harvesting, respectively relative to the comparison group. The Relative Risk Ratio (exp $^{(ß)}$) of strategy 1 indicates the relative risk that the households choose this strategy is 18.84 times greater than those who are making their living in *Dega* and *Kola*. In simple language, the RRR implies an increase in the predicted probability of selecting strategy 1 compared to the base case. Here it would appear that whereas this variable influences strategies 1 and 4, it does not play a role in determining strategy 2. With regards to the average marginal effects it is found in the present study that change from *Woina Dega* to *Dega* and *Kola* agro ecologies would increase the probability of selecting strategies 1 and 4 by 0.469 and 0.038, respectively. A finding of the present study confirms work of Temesgen et al. (2010).

Agro Ecology Kola (AEZKOLA)

This variable is positively related to the selection of adaptation strategies 1 and 4 at 5% level of significance. The conditional odds ratios or RRR of 83.16 and 86.99 for adaptation strategies 1 and 4, respectively imply that the probability of opting for these strategies are greater by 83.16 and

86.99 times relative to the base case. Simply, these would seem to suggest an increased likelihood of selecting adaptation strategies 1 and 4. Or, equivalent to this, those sample households who are making their living in *Kola* agro ecology do appear to have a higher probability of selecting and using strategies 1 and 4. Finally, the computed marginal effects reveal that change in agro ecology in which livelihoods make their living have a significant impact. This result also corroborates findings of Temesgen et al. (2010).

Family Size (FAMSIZE)

Contrary to expectation, family size is negatively associated with adaptation strategies 1 and 2 at 5% and 1% levels of significance, respectively. This implies that sample households with large family sizes and who are currently using these strategies to cope with the vagaries of climate variability and change will have a likelihood of falling back to the base case, that is, perusal of off-farm income earning opportunities. The conditional odds ratios of 0.57 and 0.58 for the strategies 1 and 2, respectively hinted that households with larger family sizes and who are using these strategies have lower probabilities of keeping on using strategies compared to sample households with smaller family sizes. Computed average marginal effect hinted that a unit increase in the family size would decrease the predicted probability of strategy 1 at 5% significance level and an extremely low effect (0.002) on strategy 2. Results obtained in the present study are in agreement with arguments of Hassan and Nhemachena, (2008) which states that households with larger family size are expected to enable farmers to implement various adaptation measures.

Sex of Household Head (SEX)

As expected, the sex of household is significantly and positively associated with strategy 1. Male headed sample households are more likely to select and use strategy 1 as compared to female headed households in the face of an ever increasing pressure on grazing resources and prevalence of severe shortage of animal feed in the study area. It is evident also that strategy 4 is labor and capital intensive adaptation strategy that may be suited to the fewer households with a better adaptive capacity. Interpretations of relative risk ratio and average marginal effect are similar to the above ones. This finding is in agreement with results obtained by Temesgen et al. (2010). These authors have argued that being a male headed household may affect the ability of a household to cope with different climate extreme events. However, this result contradicts with the finding of Apata and colleagues (Apata et al. 2009) who argued that sex has no a statistically significant relation with adaptation strategies.

Plot Size (PLOTSIZE)

Plot size is significantly and uniformly associated with the three adaptation strategies at 10% level of significance relative to the comparison group. One unique point that deserves interpretation is the computed negative marginal effect of this variable on integrated crop-livestock diversification strategy. The possible explanation is that the predicted probability would decrease as plot size increases by a unit value. Shortages of grazing land and animal feed might have contributed to a decrease in predicted probability by 0.418. This entails that sample households who are currently using strategy 2 could eventually drop out, relative to the base category.

Frequency of Extension Contact (FREXT)

Computed log-odds depicted frequencies of extension contacts to have a positive relation with all mutually exclusive strategies considered in the present study (Temesgen et al. 2010 for further evidence). The conditional odds ratio of 3.25, 3.17 and 2.72 for adaptation strategies 1, 2 and 3, respectively signify that probabilities would increase/decrease by such magnitudes. The average marginal effects are found to be positive for strategy 1 and negative for adaptation strategies 2 and 4. Compared to base category, a unit increases in the frequency of extension contact would increase the probability of adapting strategy 1 by 0.01 at 1% level of significance. Contrary to this, a unit increase in frequency of extension contact would decrease the probability of choosing strategies 2 and 4 by 0.003 and 0.004 at 1% level of significance. This result might have originated from the fact that high focus and emphasis given to the crop related technologies by the Government and extension workers compared to all other agricultural activities.

Livestock Holding (TLU)

Our results indicated that the size of livestock holding in TLU is found to positively and significantly relate to the second strategy which refers to integrated crop-livestock based diversification. Interestingly, this variable is not found to determine the remaining two adaptation strategies. The relative risk ratio for livestock holding indicates that the probability households who own more livestock and who have chosen integrated crop-livestock based diversification would be greater by 1.022 times compared to those households who do not own livestock. By the same token, compared to the base category a unit increase in TLU would increase the likelihood of adapting strategy under consideration by 0.193 at 1% level of significance. Findings of the present study are in full agreement with what have been reported by Temesgen et al. (2010) and Belaineh (2003).

Off-farm Income (OFFAR)

Contrary to our statement of theory, it is found in the present study that off -farm incomes are negatively and consistently associated with strategies 1, 2 and 4 relative to the base case. The average marginal effects are nil for all adaptation strategies included in the analysis. The result hints that entry into off-farm activities are constrained by barriers such as start-up capital and skill.

Training Participation (TRAINING)

Participation in climate variability and change related training programs is found to be negatively and significantly associated with strategies 1 and 2 at 5% level of significance. Interpretations of relative risk ratios are obviously similar to those made for other covariates in the preceding pages.

But, the negative marginal effect computed for the integrated crop-livestock based diversification strategy deserves special attention. Here, one may safely argue that the decline in predicted probability for pursuing strategy two is basically due to lack/absence of training programs in the locality with adequate coverage and contents about livestock production sub-system and/or on integrated crop-livestock systems. Obviously, this might have originated from an overemphasis given to crop production and productivity improvement efforts made by the extension agents and other officers working at various levels.

CONCLUSION

Based on the findings of the present study, we find that perceptions are nearly unified for the whole sample households including the gender and social groups. Therefore, this study concludes that there are no multiple perceptions and varying insights among rural households with regards to the subject under consideration. This has emanated from an existence of widespread covariate risks in the area as a direct result of climate variability and climate change. One of the possible explanations is that a shift from idiosyncratic risk to covariate risk due to climate change might have led to unified local perceptions instead of prevalence of multiple perceptions and varying insights among rural households. Despite the fact that, livelihoods adaptation strategies chosen are not free from constraints the study finds that a combination of several strategies are chosen by households to cope with the impact of climate variability and change. The different combinations of measures and practices are grouped into four major adaptation options: crop diversification and the use of SWC practices, integrated crop-livestock-based diversification, engagement in non/off-farm income earning activities and rainwater harvesting. So, one can safely conclude that livelihood diversification is not only a choice, but it is mandatory in order to survive in the face of an eminent climate variability and change. The multinomial logistic (MNL) regression model has deepened an understanding of the relations between various covariates and adaptation strategies commonly used in the area. Results suggest that different adaptation strategies are influenced by differing explanatory variables. Results from the multinomial logit model shows that out of 18 explanatory variables, 9 were found to be significant at 1%, 5% and 10% probability levels. These include AEZ *Woina Dega,* AEZ kola, sex, family size, plot size, non/off-farm income, livestock holding (TLU), frequency of extension contact and training. Accordingly, AEZ *Woina Dega,* AEZ *Kola*, sex, plot size and frequency of extension contacts have a significant and positive impact on crop based diversification coupled with SWC practices while family size, non/off-farm income and training have significant negative impacts. On the other hand, plot size, livestock holding (TLU) and frequency of extension contacts are significantly and positively associated with integrated crop-livestock based diversification while family size, non/off-farm income and training are significantly and negatively associated. Similarly, AEZ *Woina Dega*, AEZ *Kola*, plot size and frequency of extension contacts are significantly and positively associated with rainwater harvesting whereas off-farm income have a significant and positive relation.

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