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Research Article

Smallholder Sesame Producers' Adaptation Decisions to Climate Change and Its Determinants in Western Ethiopia

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Abstract

The agricultural sector remains the main source of livelihood for rural communities in Ethiopia, but the challenge of changing climate continues to pose a serious threat to its development. This study investigated factors affecting smallholder farmers' decisions to adopt adaptation options to climate change in West Ethiopia using data collected from 400 sampled households. The Rainfall Satisfaction Index and Multinomial Logit Model were used to analyze farmers' exposure to climate variability and factors that shape farmers' adaptation strategies. The findings of the study showed that the majority of farmers are experiencing high exposure to climate change both in terms of variable rainfall and rising temperature. In response, to adapt to the impact of climate change farmers were participating in agronomic practices, livelihood diversification, soil and water conservation, and small-scale irrigation as the dominant adaptation options. It is also observed that adopting agronomic practices was significantly impacted by social capital, crop failure experience, and access to early warning. Gender of the household, education, and livestock ownership were found to have a negative relationship with livelihood diversification. The study further revealed that soil and water conservation measures are positively affected by perception of temperature increment, exposure to early warning systems, and larger size of cultivated land. In addition, the adoption of small-scale irrigation was significantly influenced by access to credit, social capital, and the educational status of household heads. Consequently, the result implies that programs and policies designed to curb the calamities of climate change should emphasize creating effective early warning systems to increase farmer awareness, reach farmers with effective microfinance institutions, and encourage farmers' ties to many social cooperatives.

Keywords

Adoption, Adaptation Options, Determinant, Climate Change, MNL

1. Introduction

Scientific evidence revealed that the earth's climate is rapidly changing owing to increasing greenhouse gas emissions [41, 49], which led to raising the average temperature and altered the amount and distribution of rainfall globally [14, 48]. In Africa, climate change has already placed a heavy burden on the dominantly rain-fed agricultural production [10, 29], and smallholder farmers livelihoods will be further threatened by ongoing climate change [54]. Limiting the

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adverse impacts of climate change has become a global challenge that makes climate change mitigation and adaptation critical [34]. In developing countries, to ensure the livelihoods of the poor communities, adaptation of the agricultural sector to the changing climate is very essential [37].

The Ethiopia rain-fed agriculture sector, according to 2014 National Bank of Ethiopian report, accounts for about 42.9% of GDP, 80% of employment, and 88% of export earnings. Despite its key role in the country's economy, the sector is inherently sensitive and most vulnerable to climate change, characterized by low use of external inputs [12, 9, 45]. An increasing incidence of floods, droughts, and unpredictable rainfall are the main indicators of the adverse impact of climate change [44, 26]. This has resulted in recurrent food shortages and famine [35, 27], and it is still posing a serious threat to Ethiopia's development [24]. To develop resilience to climate change-related risks farmers in developing nations have been practicing diverse adaptation strategies. Likewise, in Ethiopia, climate change adaptation has become one of the widely supported policy agendas [49, 32].

Farmers' perception of climate variability and a decision to use the selected adaptation strategies are influenced by a combination of different factors [17, 46]. As climate change adaptation is mostly location-specific its effectiveness largely depends on the performance of local institutions and socio-economic settings [14]. To make policies and programs aimed at promoting fruitful adaptation options a better understanding of smallholder farmers' exposure to climate change and their efforts to adapt needs a close investigation.

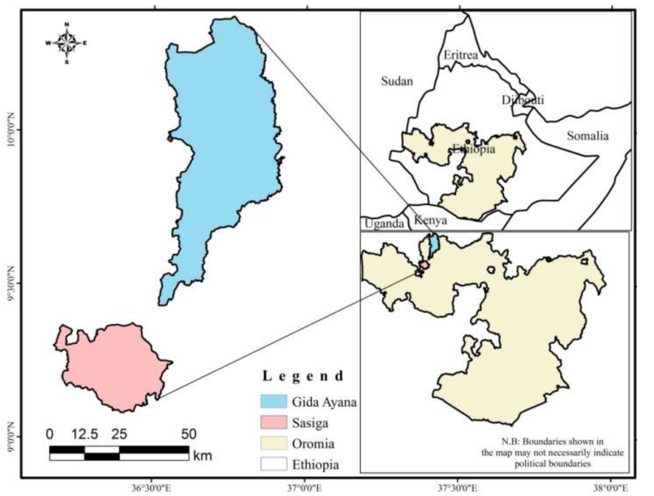
Array of studies attested to the potential adverse effects of climate change on the Ethiopian agricultural sector [39, 31, 16]. Yet, the findings of the studies were mainly focused on the impact of climate change on agricultural production and suggested adaptation strategies. However, they failed to deal with the driving forces that determine a household's choices of adaptation options. This indicates a wide gap or limitation to better understand adaptation practices and challenges on the ground. Additionally, other studies have tried to assess the impact of climate change and determinants of adopting adaptation measures in mono-crop and mixed-crop production systems at the regional level in Africa [39, 46, 47]. Due to the aggregate nature of these studies, however, it becomes cumbersome to address heterogeneity in agro-ecological features, socioeconomic, institutional, and environmental issues. This has limited an effort to understand the contribution of adaptation strategies, as the adoption of adaptation strategies to climate change is context specific.

Further, few studies [17, 6, 15] investigated factors affecting the choice of adaptation methods. Nonetheless, they are far from reaching on similar consensus and revealed disparity in factors that influences farmers' decision to practice different adaptation methods in various areas of studies. This gap in obtaining clear scientific evidence has become stumbling block for the efforts to design appropriate development policies and interventions. Therefore, context specific assessment of the determinants of smallholders' decision in response to climate change is decisive to pinpoint main practices that could improve the use of appropriate adaptation strategies. Accordingly, the objectives of this study were to assess farmers' exposure to changing climate, to identify adaptation strategies used by dominantly sesame producers' smallholders and to analyze factors that influence smallholder farmers' decisions to adopt various adaptation strategies in West Ethiopia.

2. Methodology

2.1. Description of the Study Area

This study was undertaken in the west of Ethiopia, in the East Wellega Zone in the Oromia region. The zone is geographically located between 9°31' 9" North latitude and 36° 45' 27" East longitude. Based on the 2007 Census conducted by the Central Statistics Authority, this zone had a total population of 1,213,503 (606,379 men and 607,124 women) with an area of 12,579.77 square kilometers and a population density of 96.46. There are 18 districts in this zone and Sasiga and Gida Ayana districts were selected for this study.



Source: Author's Production

Figure 1. *Location of the study area in Oromia regional state.*

According to data from the Rural and Agricultural Development Office the total population of Sasiga woreda was 80,814 (41,326 men and 39,488 women); 2,573 or 3.18 percent of its population was urban dwellers. A survey of the land in this woreda showed that it had 11.9 percent arable or cultivable land, 2.8 percent pasture land, 1.6 percent forests, and the remaining 83.7 percent was swampy and marshy or otherwise unusable. On the other hand, the total population of Gida Ayana district was about 142,408 of which 66,918 (47 percent) were women and 75,490 (53 percent) was men. A survey of the land in this woreda showed that 65.7 percent of the land was arable or cultivable (61 percent was under annual crops), 22.8 percent was pasture land, 8.7 percent was forests, and the remaining 2.8 percent was unusable. Sesame and khat are two important cash crops in this woreda (Figure 1).

2.2. Methods of Data Analysis

Climate change adaptations framework: In this study, climate change adaptation strategies are modeled under the standard farm technology adoption framework. Representative risk-averse farm household face problem of choosing one or more climate change adaptation strategies that maximize the expected utility from final yield given production function, climatic condition, land, labor and other constraints. Optimization solution would result in an optimal adaptation measures undertaken by the representative farm household. Hence, the household's choice of climate change adaptation strategy is affected by a set of climatic as well as various socio-economic factors.

$$\text{That is: } A_{ih} = f\left(H_h, I_h, C_h, R_h\right)$$

Where, $A_{ih} = i^{th}$ adaptation strategy to climate change adopted by household h, H_h is a vector of household's characteristics including household size, household head's gender, age and educational level, I_h is a vector of access to both formal and informal institutions such as access to extension services, access to credit and local market for input and output, C_h is a vector of climatic variables and access to climate related information and R_h is a vector of human and capital assets such as labor and land ownership.

Besides, representative utility maximizing household is supposed to choose one climate change adaptation strategy over another if and only if the expected utility or gain in farm yield derived from one adaptation strategy is greater than the expected utility in farm yield from the other. For instance, a rational farm household chooses soil and water conservation over agronomic practices if and only if he expects more yield gain from adopting the former strategy than the latter.

Furthermore, in this study, it is assumed that household's decision to adopt or not to adopt a given adaptation measure is made at household level but not at specific plot level. Moreover, to be methodologically consistent, sample farmer households were asked questions about what adaptation measures and practices they have typically used in order to cope with the negative impact of climate changes. This enables us, in model specification, to take a single dominant adaptation strategy from multiple strategies that the farmers have been applying in response to climate change. A dummy variable is designed to measure whether farm households had adopted each adaptation in any of their farm so as to cope with observed climate change and variability. Hence, each adaptation strategy is measured at household level and modeled independently. Finally, multinomial logistic regression model is used to investigate the factors affecting households' decision regarding choice of adaptation strategies to climate change as identified in equation above.

Multinomial logit model specification

Literatures indicate two broad groups of adoption models based on the number of choices or options available to an economic agent [28]. Binary models are very popular due to their desirable statistical properties of bounding probabilities between 0 and 1. Nevertheless, since a choice decision by farmers is inherently a multivariate decision using bivariate modeling excludes useful economic information contained in the interdependent and simultaneous choice decisions [22]. Therefore, in order accommodated farmers' decision of using multiple adaptation options in which the dependent variable is discrete, it is more appropriate to consider adaptation options as a multiple choice decision. Therefore, the appropriate econometric model would be either multinomial logit or multinomial probit regression model. Regarding estimation, both of them estimate the effect of explanatory variables on dependent variable involving multiple choices with unordered response categories [28]. In this study, therefore, the determinants of farmers' adaptation decisions to climate change were analyzed using a multinomial logit (MNL).

This random utility model is commonly used as a framework in determining of farmers' choice for different adaptation options (sources). Following [28], suppose for the i^{th} respondent faced with j choices, we specify the utility choice j as:

$$U_{ij} = X_{ij}\beta + \varepsilon_{ij}$$

If the respondent makes choice j in particular, then we assume that U_{ij} is the maximum among the j utilities. So the statistical model is derived by the probability that choice j is made, which is:

$$\text{Prob } (U_{ij} > U_{ik}) \text{ for all other } k \neq j$$

where U_{ij} is the utility to the i^{th} respondent from adaptation strategy j, U_{ik} the utility to the i^{th} respondent from adaptation strategy k.

If the household maximizes its utility defined over income realizations, then the household's choice is simply an optimal allocation of its asset endowment to choose adaptation strategy that maximizes its utility. Thus, the i^{th} household's decision can, therefore, be modeled as maximizing the expected utility by choosing the j^{th} adaptation strategy among J discrete adaptation strategies, i.e.,

$$\max_j = E(U_{ij}) = f_j(X_i) + \varepsilon_{ij}; \quad j=0...J$$

In general, for an outcome variable with J categories, let the

j^{th} adaptation strategy that the i^{th} household chooses to maximize its utility could take the value 1 if the i^{th} household chooses j^{th} adaptation strategy and 0 otherwise. The probability that a household with characteristics X chooses adaptation strategy j, P^{ij} is modeled as:

$$P_{ij} = \frac{\exp(X_i^{'}\beta_j)}{\sum_{j=0}^{J}\exp(X^{'}\beta_j)}, \quad J = 0...3$$

With the requirement that $\sum_{j=0}^{J} P_{ij} = 1$ for any i, where P_{ij} = probability representing the i^{th} respondent's chance of falling into category j; X = predictors of response probabilities, β_j = Covariate effects specific to j^{th} response category with the first category as the reference.

To removes indeterminacy in the model an appropriate normalization is to assume that β_1=0 (this arise because probabilities sum to 1, so only J parameter vectors are needed to determine the J + 1 probabilities), so that $\exp(X_i\beta_1) = 1$, implying that generalized Eq. (4) above is equivalent to

$$\Pr(y_i = j / X_i) = P_{ij} = \frac{\exp(X_i\beta_j)}{1 + \sum_{j=1}^{J}\exp(X_i^{'}\beta_j)}, \quad \text{for j} > 1$$

where y is a polytomous outcome variable with categories coded from 0… J.

Unbiased and consistent parameter estimates using MNL model assumes the Independence of Irrelevant Alternatives (IIA) that requires that the probability of using a certain adaptation method by a given household is independent from the probability of choosing another adaptation method. Hausman test was used to test the validity of the IIA assumption. On the other hand, the estimated coefficients of the model provide only the direction of effect of independent variables on dependent variables, but neither represents the actual magnitude of change nor probabilities [56]. Thus, we used the marginal effects measure of the expected change in the probability of a particular choice being made with respect to a unit change in an independent variable [28].

Indicators of climate change Vulnerability (Exposure)

Sensitivity, exposure, and adaptive capacity are the key factors that determine the vulnerability of households and communities to the impacts of climate change [4]. It is also indicated that exposure to impacts of climate change are a good indicator in the vulnerability assessment. In this study, we adopted the exposure factor to assess smallholders' vulnerability to climate change. Though not compressive, it is believed to be good enough to understand households' vulnerability to the climate impacts. Therefore, indicators of exposure factors are identified as essential elements of a basic vulnerability assessment.

Exposure is the nature and degree to which a system is exposed to climate variations [4]. Temperature and precipitation are critical parameters of climate which strongly influence people, biodiversity, and ecosystems. It is generally agreed that increasing temperature and decreasing precipitation are both damaging to the already hot and water scarce agriculture [24]. Exposure indicators selected for this study characterize the frequency of extreme events, a warning system for natural disasters, and variations in temperature and rainfall. Thus, reduced and variable precipitation and increased temperature in the study area show a high level of exposure to climate change.

2.3. Definition of Variables and Hypothesis

The potential explanatory variables, which were hypothesized to influence farmers' use of adaptation options in response to climate change and considered in the analysis, are often classified as personal, socioeconomic, institutional, and climate factors [50, 8]. As depicted in Figure 2 below the dependent variable in this study was the choice of an adaptation option. Table 1 presented the description, definition and unit of measurement for both explanatory and dependent variables. Additionally, the expected effects of explanatory variables along with source of literature were also given in the table below.

Table 1. *Descriptions, definition, and values of variables used in empirical model.*

Variables	Definition	Value and unit of measurement	Effect	References
Dependent variable				
Adaptation options	Adaptation options	It is a categorical variable which takes the value 0 for not using any adaptation option, 1 =adopting agronomic practices, 2 =using different livelihood diversification strategies, 3 = using soil and water conservation measure, and 4 = using small-scale irrigation		
Independent varia-				

Variables	Definition	Value and unit of measurement	Effect	References
ble				
Genderhh	Gender of the household head	It is dummy variable which takes the value 1 for male and 0, otherwise	"+", "-"	[4, 17, 19]
Agehh	Age of the household head	It is a continuous variable measured in years	"+", "-"	[2, 3, 21]
Education	Education status of the household head	It is continuous variable measured in years of schooling	"+"	[3, 13, 55]
Family Size	Number of family members	Refers to the number of members who are currently living within the family	"+", "-"	[6, 21, 55]
Farmsize	Hectare of land cultivated	It is continuous variable measured in hectare	"+", "-"	[5, 25, 30]
Livestocktlu	Number of livestock owned by the household	It is continuous variable measured in TLU using conversion factors (Annex)	"+", "-"	[2, 23, 52]
Social Capital	Number of social groups which a household head has a membership	It is dummy variable which takes value 1 if a household head is membership to greater than or equal to two social groups and 0 otherwise	"+"	[11, 20, 55]
Access Credit	Access to credit services	It is a dummy variable, which takes the value 1 if the farm household access to credit and 0 otherwise	"+"	[17, 19, 55]
Access to Extension Services	Access to extension services	It is a dummy variable, which takes the value 1 if the farm household access to extension service, and 0 otherwise	"+"	[3, 5, 55]
Market Distance	Distance from the nearest market	It is a continuous variable measured in walking km from home to the nearest market	"-"	[18, 33, 38]
Crop Failure	Frequency of number of droughts over the past 20 years	It is continuous variable measured in number	"+"	[53]
Temprature Perception	Perception of households change in temprature over the past 20 years	It is a dummy variable, which takes the value 1 if the farm household percieve increase in temperature, and 0 otherwise	"+"	[37]
Warning System	Receive a warning about the flood/drought before it happened	It is a dummy variable that takes the value 1 if the household receives a warning about drought/floods before it occurs, and 0 otherwise	"+"	[19, 38, 55]

3. Results and Discussion

3.1. Smallholders' Exposure to Climate Change

In this study, two climatic variables namely precipitation and temperature were chosen to measure the vulnerability (exposure) of farm households to climatic shocks. Regarding rainfall situation five questions were included in the questionnaire following [1]. These questions include: Did the rainfall come on time? Was there enough rain on your fields at the beginning of the rainy seasons? Was there enough rain on your fields during the growing seasons? Did the rains stop on time on your fields? Did it rain during the harvest periods? A household was asked each of these questions. Then, value1 is assigned if a household experience timely, regular and sufficient rainfall during ploughing, planting, crop growing and harvesting periods and 0 otherwise. Finally, all responses were added up and divided by 5 to form subjective rainfall satisfaction index. The index value is specific to observed rainfall variability at each household's farm where lower values indicate higher vulnerability to rainfall shock and higher values indicate good farm-level rainfall conditions. Though subjective, this seems to be an appealing measure of observed rainfall conditions because farmers have been farming for a generally long period and experienced real conditions of climate on their specific farms.

Then rainfall variability was proven using farmer subjective observation regarding timeliness and amount of rainfall in the area. Responses indicate high rainfall variability and unpredictability during the planting, crop growing, harvesting and post-harvesting periods. Though the majority of the respondents report that rainfall is coming on time, nearly 40% of the respondents' experience insufficient rainfall during the crop planting period (see Table 2). This is unfavorable condition for agricultural production that can reduce crop yield by affecting the early stage of growth. It also harms livestock production by affecting forages and grasses recovery, and growth. Additionally, more than 45% of the respondents have been observed too early and or too late stop of rain. Rain was not stopping on time for them it was quitting either too early or too late. These unfavorable rainfall conditions would aggravate the food insecurity problem leaving a significant proportion of sampled farm households vulnerable to risks of harvest loss of weather variability and climatic change.

Table 2. *Observed rainfall amount and regularity in study villages.*

On your farms	Favorable Conditions (Percentage)		Unfavorable Conditions (Percentage)	
Rainfall coming on time	*Yes (on time)*	*(74.6)*	*No (too early + too late)*	*(25.4)*
Enough rain at the beginning of rainy seasons	*Yes (enough)*	*(62.7)*	*No (too little + too much)*	*(37.8)*
Enough rain during growing seasons	*Yes (enough)*	*(79.3)*	*No (too little + too much)*	*(21.7)*
Rains stopping on time	*Yes*	*(54.3)*	*Too early + too late*	*(46.7)*
Rain during harvest periods	*No*	*(62.8)*	*Yes*	*(38.2)*

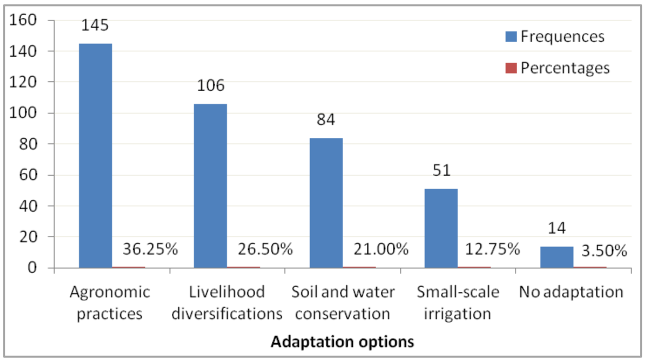
Source: Computation based on survey data, 2017

On the other hand, farmers were asked pattern of temperature change they have been noticed over the last two decades. Majority of them (83.75%) responded that temperature is increasing while 15.5% said it is decreasing. We further asked the farmers directly if they are facing climate change or not. 92.8% of them claimed that the climate change is the reality that they have been facing timely and again. And then, sample farmer households were asked questions about what measures and practices they have typically used in order to cope up with the negative impact of climate changes.

3.2. Adaptation Strategies of Smallholder Farmers to Climate Change and Variability

This section briefly summarizes farmers' adaptation strategies in response to climate change based on data from a comprehensive survey of agricultural households. The results show that adaptation strategies farmers used include using stone bunds; check dams; terraces; small-scale irrigation; drought-tolerant and/or improved crop varieties; crop diversification; and off-farm activity. For the convenience of model analysis, the identified adaptation strategies are combined into five categories including the 'no adaptation' category. The use of drought-tolerant crop varieties, crop diversification, and improved crop varieties have merged and categorized as an agronomic practice. Likewise, the use of off-farm activities is merged into a livelihood diversification component. Also, stone bund, check dam, and terrace are grouped into soil and water conservation (SWC) measures.

Agronomic practice measures (36.25%) and livelihood diversifications (26.50%) were the two most widely used adaptation strategies in the study area (see Figure 2). To minimize the risk from the total loss of crop production and to increase crop productivity, farmers' diversified crops grown on the same plot of a farm, used drought-tolerant crop variety, and improved crop variety. Smallholder farmers were also engaged in diversifying their livelihood strategies using off-farm activities in addition to their farming practices. Farmers have also been using different livelihood strategies such as SWC and small-scale irrigation as a vitally important adaptation strategy in the face of the uncertainties due to climate variability (Figure 2).



Source: Computation based on survey data, 2017

Figure 2. *Adaptation strategies used by smallholder farmers.*

It is also found that about 21% of the farmers started implementing SWC. They mostly apply stone bund, soil bund, check dam, and terrace. The use of these strategies was found to reduce soil erosion associated with short but heavy rains which are usually common in the study areas. Farmers also employed small-scale irrigation schemes (12.75%) over their farms as another important strategy in their efforts to adapt to the effects of climate change. On the other hand, the number of farmers who did not adjust their farming practices in response to climate variability was found to be small (3.50%). They cited the shortage of sufficient financial resources, lack of climate-related information, and shortage of land as the main reasons for not adopting.

3.3. Determinants of Farmer' Adoption of Climate Change Adaptation Measures

Prior to running the MNL model, multicollinearity was checked using VIF and CC. The results from VIF values have shown that VIF for all variables is on average 1.03, which indicate all the continuous explanatory variables have no serious multicollinearity problem. Similarly, values of the CC have shown no multicollinearity problem among dummy variables. Additionally, we used Hausman test to test for the validity of the IIA assumptions. The result of the test show that it failed to reject the null hypothesis of independence of the climate change adaptation options, suggesting that the MNL model specification is appropriate. The likelihood ratio statistics as indicated by Chi-square statistics are highly significant ($p < 0.01$), suggesting the model has a strong explanatory power. Moreover, to estimate the multinomial logit model, we considered the fifth category (no adaptation) as a base category. Table 3 below presented the estimated coefficients of the MNL model, along with the levels of significance. The marginal effects from the MNL, which measure the expected change in the probability of a particular choice being made with respect to a unit change in an independent variable, were reported and discussed in Table 4.

Household Characteristics

Gender is found to be positively and significantly related to the adoption of agronomic practices 1% significance level. Men are 29.55% more likely than female to adapt agronomics adaptation practices. These results are in conformity with the previous that due to cultural and social barriers that limit women's access to land and information using agronomic practices [4, 19]. On the contrary, female headed household adapt more readily to climate change using livelihood diversification. This is probably due to the fact that women do much of non-agricultural works in the study area. This is consistent with the prior argument by [38], which revealed that female-headed households are more likely to take up climate change adaptation methods.

The result shows significant impact of education on farmers' decision to adopt small-scale irrigation. A unit increase in a number of years of schooling would result in a 0.81% increase in the probability of small-scale irrigation to adapt to climate change. This may be due to the fact that education helps farmers understand the potential benefit of small-scale irrigation to minimize the possible impact of climate change. This result agrees with previous studies [56, 3, 13]. Further, opposite to our expectation, level of education negatively and significantly ($p < 0.1$) determines farmers' decision to adopt livelihood diversification strategies such as off farm activities. This can be explained by the fact that educated households may have realized higher earnings from on-farm activity than off-farm that may have low return.

Resource Endowments

The result of the study indicates that a unit increase in a hectare of cultivated land would decrease the likelihood of using different agronomic practices by 30.3%. This might be because farmers with a large size of cultivated land have less fear of taking the risk of climate change than their counterparts. This is consistent with the finding of [18] and inconsistent with other studies [25, 10, 42]. According to Phillipo, households with small land holdings are more likely to choose traditional crop varieties because of the associated costs to the new crop varieties. On the other hand, the study reveals that the size of cultivated land significantly increases the likelihood of using soil and water conservation measures at 1% significance level. This may be due to the reason that farmers with large farm size have less risk of reduction to farm size that came out from constructing SWC measures on their farm land. Previous literatures also support this result [2, 30, 25].

Livestock holding in TLU negatively influences household's choice of livelihood diversification strategies at 5% probability level. This result indicated that a unit increase in a number of livestock in TLU would result in a 5.1% decrease in the probability of creating another source of livelihoods like petty trading and small business as an alternative means of income. It is understood from this that farmers with lower livestock holding would be obliged to diversify livelihoods into non-farm to meet needs. This result differs from the view that higher livestock ownership would help farmers more likely to have better financial sources helping them to create another source of livelihood [51].

Institutional Factors

Being membership of many social groups organized at the local level, as a proxy for social capital, is positively related to the likelihood of adoption agronomic practices and small-scale irrigation at 5% and 10% significance level, respectively. A unit increase in membership to the social group would result in 14.71% and 6.47% increase in the probability of adopting agronomic practices and small-scale irrigation, respectively. The possible explanation of this result is social capital increase awareness and use of climate change adaptation options. In line with this, [40, 36] found that being a member of the social networks have substantially increased the likelihood to adopt improved and high yielding varieties. Other studies also confirmed this fact [17, 36].

Having access to credit increases the probability of adoption of small-scale irrigation by 13.93%. This can be justified by the fact that availability of credit minimizes liquidity constrains and thereby enhances farmers to purchase irrigation facilities. Similar results were reported in the previous studies [17, 56, 25]. The study result reveal that access to early warning about drought and flood has a significant and positive impact on the likelihood of using agronomic and SWC practices. As indicated, getting access to climate warning increases the likelihood of using agronomic practices (13%) and SWC measures (11.3%). Study by [42] noted that information on climate warning empowered smallholder farmers to adapt to climate variability and change. Similarly, [19] found that access to information on climate change has a significant and positive impact on the probability of using different crop varieties.

Table 3. Parameter estimates of the multinomial logit climate change adaptation model.

Adaptation Options	**Agronomic Practices**		**Livelihood Diversification**		**Soil and Water Conservation**		**Small-Scale Irrigation**	
Explanatory Variables	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value
Male HH	-12.121	0.985	-13.784	0.983	-13.842	0.983	-13.736	0.983
Age HH	0.026	0.418	0.019	0.563	0.02	0.557	0.014	0.676
Education	0.461***	0.005	0.404**	0.014	0.440***	0.008	0.505**	0.003
Family Size	-0.315***	0.008	-0.320***	0.007	-0.330**	0.010	-0.341***	0.008
Farm Size	0.884**	0.011	0.946***	0.007	1.086***	0.002	1.007***	0.004
Livestock TLU	0.792**	0.042	0.524	0.180	0.742*	0.067	0.654*	0.105
Social Capital	-0.017	0.985	-0.320***	0.007	-1.176	0.226	0.157	0.879
Credit	0.271	0.731	0.412	0.603	0.213	0.799	1.454*	0.079
Training	-1.601*	0.081	-1.656*	0.071	-1.205	0.205	-1.071	0.266
Distace Market	-0.207	0.200	-0.065	0.676	0.208	0.169	-0.022	0.893
Crop Failure	0.196*	0.088	0.178	0.122	0.188	0.114	0.126	0.290
Temprature Percepition	0.661	0.443	0.695	0.423	2.381**	0.034	0.343	0.712
Warning	2.045*	0.057	1.222	0.248	1.940*	0.087	0.877	0.430
_cons	8.741	0.989	12.122	0.985	7.638	0.990	9.911	0.988
Base category no adaptation								
Number of obs. 400								
LR x2 (52) 235.99								
Prob> x2 0.0000								
Log likelihood -452.984								
Pseudo- R2 0.2067								
***, **, * significant at 1, 5 and 10 probability level, respectively. HH is Household Head								

Table 4. Marginal effects from the multinomial logit of climate change adaptation model.

Adaptation Options	**Agronomic Practices**		**Livelihood Diversification**		**Soil and Water Conservation**		**Small-Scale Irrigation**	
Explanatory Variables	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value
MALE HH	0.2955***	0.000	-0.1526*	0.082	-0.0881	0.275	-0.0475	0.419
AGEHH	0.0018	0.403	-0.0006	0.775	-0.0004	0.826	-0.0008	0.589
EDUCATION	0.0085	0.222	-0.1053*	0.105	-0.0064	0.273	0.0081**	0.047
FAMILY SIZE	0.0052	0.619	0.0010	0.919	-0.0041	0.666	-0.0023	0.730

Adaptation Options	Agronomic Practices		Livelihood Diversification		Soil and Water Conservation		Small-Scale Irrigation	
FARM SIZE	-0.3028**	0.030	-0.0025	0.818	0.0279***	0.001	0.0064	0.275
LIVESTOCK TLU	0.3388	0.141	-0.0507**	0.028	0.0256	0.203	-0.0056	0.690
SOCIAL CAPITAL	0.1471**	0.035	-0.0960	0.193	-0.1205	0.112	0.0647*	0.094
CREDIT	-0.0639	0.262	-0.0278	0.609	-0.0556	0.234	0.1393***	0.002
TRAINING	-0.0083	0.888	-0.0260	0.630	-0.0249	0.607	0.0556	0.121
DISTACE MARKET	-0.0370**	0.021	0.0096	0.459	0.0178*	0.102	0.0098	0.210
CROP FAILURE	0.0100*	0.109	0.0032	0.595	-0.0085	0.136	-0.005	0.220
TEMPRATURE PERCEPTION	-0.0834	0.330	-0.0487	0.548	0.2181***	0.000	-0.0677	0.293
WARNING	0.1302*	0.086	-0.1187	0.157	0.1131**	0.037	-0.1113	0.122

***, **, * significant at 1, 5 and 10 probability level, respectively. HH is Household Head

Market factors

The number of times a household's crop failed due to the adverse impact of climate over the last 20 years has positively impacted farmers' decision to adapt to climate change using agronomic practices. It can be perceived from this that farmers who experience crop loss because climate-related hazards have developed their indigenous knowledge and innovations to respond to the risk. The result is in line with the findings of [53].

Distance from the home of a household to the main market was found to have a significant ($p < 0.05$) and negative effect on the likelihood of choosing different agronomic practices. Numerous literatures indicated that improving market access for smallholder farmers would increase their ability to adapt to climate change [18, 43]. On the other hand, contrary to what one would expect, distance to the main market is found to be positively and significantly affect the rural households' decision to invest in SWC at 10% level of significance. This may be explained by the fact that households in the remote area have less opportunity cost to adapt labor-intensive adaptation practices (e.g., SWC).

4. Conclusions and Policy Recommendations

The results show that the majority of the farmers of sesame producers have perceived changes in rainfall, increment of temperature and experienced the effects of a changing climate over periods. The farmers are trying to adapt through the use of the main adaptation strategies that are broadly categorized in to, agronomic practices, livelihood diversification strategies, small-scale irrigation, and SWC measures. It is observed that adoption of these strategies tends to reduce a high production risk imposed by climate change.

Farmers' capacity to choose effective adaptation options is negatively influenced by household characters, as well as positively by farm size, social capital, access to credit and markets, access to climate information, and early warning. This urges for smallholders' local adaptation strategies augmentation by a wide range of institutional, policy, and technology support. Policy interventions which encourage farmers' membership to many social groups, creating access to market and irrigation facilities can promote and enhance adaptation to climate change. Provision of microcredit facilities can help the households to invest in small-scale irrigation. Moreover, providing timely climate change information and effective early warning system is of paramount importance to bring desired impact on the adoption appropriate adaptation options.

Conflicts of Interest

The authors declare no conflicts of interest.

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