FARMER'S PERCEPTION ON CLIMATE CHANGE AND DETERMINANTS OF ADAPTATION STRATEGIES IN ETHIOPIA: EVIDENCE FROM *WEGERA* DISTRICT

Tesfaye Sisay Mengistu
College of social science and humanities
Department of Development and Environment Management Studies,
University of Gondar, Ethiopia

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ABSTRACT

This study aims to assess the effects of climate change on smallholder farmers' livelihood inWogera district central Gondar, Ethiopia. Systematic random sampling method was used to select 333 sample households. Structured and semi-structured questionnaires were distributed for these sample households for interview. The analysis of data was done by using a descriptive statistics FGD, key informant interview; Mann-Kendall test and multinomial logistic regression model were employed. This study revealed that 83.90% *of the respondents perceived that there is a change in climate parameters overtime. Temperature and rainfall variation are the dominant climatic variables in the study area. The respondents perceived that, due to the effects of climate change decline in crop yield, food shortage, death of livestock, health problem, decline in consumption and water scarcity are common problem in the study area. The results of this study also showed that education attainment, farming experience, access to extension services, access to climate information and credit access are positively to enhance farmers' adaptive capacity to climate change and variability. However, farm land size, and access of adequate water have decreased the farmers' tendency to adopt various adaptation strategies in the study area. Therefore, this study suggested that introducing and integrating the various adaptation techniques considering the determinants can enable smallholder farmers to design best climate change adaptation strategies.*

Key word: climate change, perception,climate vulnerability, adaptation, determinant factors

BACKGROUND OF THE STUDY

Smallholder farm households in Sub-Saharan Africa experience many shocks that results to a wide variability in their agricultural production. This often causes them to be vulnerable to food insecurity and poor livelihood. The major risk factor for the vast majority of farmers practicing dry-land farming is the unreliability of the rainfall and the high frequency of drought. Ethiopia is one of the most vulnerable to climate change with least capacity to respond to vulnerability in Africa. It is highly sensitive to modest changes in climate and the ability to adapt is severely constrained (Abebe & Bekele, 2017).

The climate of Ethiopia is characterized by showing high variability annually, seasonally and geographically. Especially the amount and seasonal distribution of precipitation are varying annually and difficult to predict, while the temporal distribution of rainfall during the growing season is an important factor influencing crop yield (Belay Simane et al., 2016).

Evidence has showed that the global climate is changing and that greenhouse gases emissions are growing alarmingly leading to rise in the earth's temperature. This, intermingled with rapid population growth, threatens food and livelihood security for a large number of people, especially those in the developing countries including Ethiopia. Increasing temperatures, declining and more unpredictable rainfall, more frequent extreme weather and higher severity of pests and diseases are among the drastic changes that impact food production(Tesfaye & Seifu, 2016).

In Ethiopia, agriculture accounts about 42 percent of the GDP, employs about 85 percent of the labor force and contributes around 90 percent of the total export earnings of the country. The sector is dominated by over 15 million smallholders producing about 95 percent of the national agricultural production (Kelelew, Haji, & Girmay2, n.d.).

Because of the huge contribution of agriculture to Ethiopian's economy and its high susceptibility to climate change and climate-related extreme events– droughts and floods, it is important to study adaptation strategies to overcome the anticipated adverse impacts. It has been recognized that adaptation to climate change and variability is one of the policy agenda widely supported to help smallholder farmers to limit the negative effects of climate change in this sector (Amare & Simane, 2017).

Studies (Nkondze et al., 2018) show that the use of improved crop varieties, planting short season variety, soil conservation practices, growing drought resistant crops, and adjusting planting dates are the most important adaptation strategies by smallholder farmers

However, adaptation decision is location-specific and influenced by key drivers such as socio-economic, environ- mental, and institutional factors. Based on (Asrat & Simane, 2018),adaptation at farm-level involves two stages: perceiving a change in climate and deciding whether to adopt or not (including which adaptation strategy to use). Nevertheless, perception is not a sufficient condition for adaptation since farmers who have perceived the change in climate may not adapt or the nature of their adaptation response may vary as a result of a complex interplay among social, economic, environmental, and institutional factors(Amare & Simane, 2017). In*Wegera*districtthe use of adaptation practices and actions are often portrayed as re-active for immediate response to climate change occurrences, which are imposed without understanding the past environmental characteristics of an area.

Therefore, the aim of this study was to assess Farmers' perception of climate change and determinantsfor adaptation strategies toin*Wogera* district central Gondar, Ethiopia

MATERIALS AND METHODS

Description of the study area

Location

Description of the study area the study was carried out in *Amhara* province, Ethiopia, within *Wegera* district. *Wegera*District is situated in the North western part of the *Amhara* Province the district is located in the East *Janamora*, Western Gondar *zuria* and *lay armachiho* ,North *Dabat*and in the Southern part of *Belesa* district and also has 41*kebele* .

The total area of the district is about 182103heactar and 42km far from Gondar town. The total population of the district is 249,297 from this urban dowlers of male is and female is25, 043 and from rural dowlers male and female is 224,254.

As reported by Agricultural and rural development office, agro climate conditions of the district are 33% *W/degas*, 44% *Degas* and 23% *kola*. In addition to this geographical setup of the area is 50% flat 25% mountain 15%undulate and 10%others *Wegera*.

However, this district is characterized by low rainfall (between 400mm to 700mm per year), resulting in limited water resources causing severe water shortages and regular drought conditions particularly in the lower-lying areas of the district.

As reported by the Agriculture and rural development office, were the most vulnerable to climate change experiencing extreme climatic risk as well as high climate variability in the province.

Method of data collection

The research type which had been applied in the study include both longitudinal studies (time series data) that was collected from national metrological service agency (NMSA) of Ethiopia for over a period of 35 years particularly rainfall, and temperature records from meteorology stations. Cross sectional study design was also used to collect for socio-economic data at one point in time.

The study mainly used primary data that were collected from sample farm households in the study area. The research was conducted in two administrative *kebeles* of *Wegera* district from Central Gondar Zone which has been severely affected by climate change incidents. Representative *Kebeles* were purposely selected to take sample respondents. Each *Kebeles* differ interims of accessibility and vulnerability to climate change. Therefore, the selection of study schemes is based on accessibility, vulnerability and sensitivity of communities to the effects of climate change. Accordingly all the two *kebeles* were selected and sample respondents were randomly employed using simple random sampling technique in collaboration with the respective development agents, where every household heads in each *kebeles* had been given equal chance of selection. A visit was made to the selected *Kebeles* and household heads.

Finally, samples of 333 farm households were included in the survey using random sampling and probability proportional to size technique. As a result, 143 of sample farm households were female headed and the remaining 190 were male headed.

A pretested structured questionnaire was used to collect primary data at household level. The questionnaire contained information on a variety of topics including on household demographic characteristics, resource endowments, production, income, agricultural services etc.

Moreover, key informant interviews and focus group discussions were employed for each selected PAs. The underlying premise of using focus group discussion was to stimulate free discussion that generates fresh ideas and insights. In selection and invitation of the members of the focus group discussants consultation was made with the local DA's. For the purpose of this study, different focus group discussions were undertaken that include traditional leaders, women, men and youth.

Data analysis

A Statistical Package for Social Sciences (SPSS) version 20 was used for questionnaire data analysis. Focus group discussions and secondary data were analyzed through content analysis by identifying themes, concept, patterns and trends.

Mann-Kendall trend test is a non-parametric test commonly employed to detect monotonic trends in series of environmental data, climate data or hydrological data. MK test has been used to detect the presence of mono- tonic (increasing or decreasing) trends in the study area and whether the trend is statistically significant or not. Since there are chances of outliers to be present in the dataset, the non-parametric MK test is useful because its statistic is based on the (+or -) signs, rather than the values of the random variable, and therefore, the trends determined are less affected by the outliers(Asfaw, Simane, Hassen, & Bantider, 2018) .

Multinomial logit regression model was used to analyze the factors influencing the choice of climate change adaptation strategies by smallholder farmers. The estimation of the Multinomial logit regression model was made analyzing several variables while normalizing one variable (reference or base category). In this study, the category "not adapting" to climate change variability was used as the reference category.

RESULTS AND DISCUSSIONS

Analysis farmers' perceptions of changes in climate *Wogera* district

In order to assess farmers' perceptions of climate change and variability, Mann-Kendall test was undertaken for linear trend in annual means of temperature and total annual rainfall. Descriptive statistics based on summary counts of the questionnaire structure are used to provide insights into producers' perceptions of climate change and variability. In the

literature several studies have undertaken similar type of analysis. For instance, study by by(Nkondze et al., 2018) assessed farmers' perception of changes in temperature and rainfall in the *Woleka* district in Ethiopia they observed that of farmers interviewed perceived an increasing temperature and a decreasing precipitation.

Temperature Changes

.About83.90% of the farmers they perceive any change in temperature in the district, 11.86% of the farmers perceive there is decreasing of temperature in the district, while only 4.24% noticed the contrary, about an increasing or decreasing of temperature in the district.

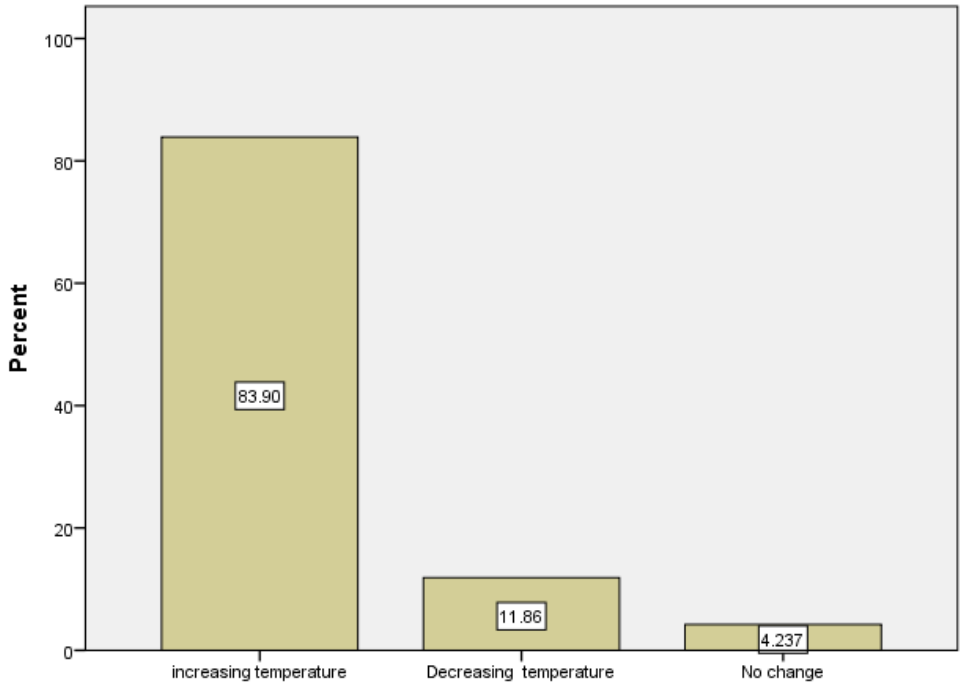

Figure 1: farmers perceptions of changes in temperature

Temperature trend analysis

As known, temperature is a critical determinant of plant and animal growth and survival. For all organisms, we can determine upper and lower lethal temperatures, in addition to upper and lower critical temperatures.

Temperature conditions are often viewed as 'favourable' and little consideration is given to -temperature alone, particularly in tropical areas where temperature rarely changes markedly. However, temperature analysis can be important in many situations where crops, livestock, stored products, pests and diseases are all affected by the temperature conditions.

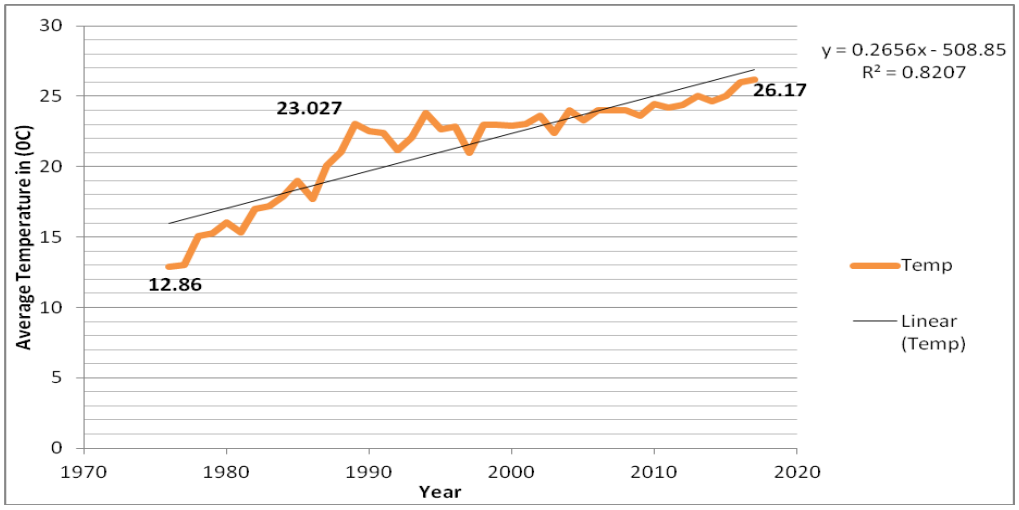

Figure 2 Temperature Trends of Wogera district

As it has been explain from the above graph, average annual temperature has been increasing from time to time, which actually is being substantiated with strong coefficient of determination value greater than 0.5 (i.e. $R^2 = 0.8$).

Table 1: Average temperature data 1976-2017 of *Wegera district* Station

Variable	Observations	Minimum	Maximum	Mean	Std. deviation
Average Temperature	41	10.2	32.14	21.24	3.59

The most common form of climatic data, available for Wegera district is summaries of monthly averages of temperature. Mean annual temperature has increased 0.3251°C per annum since 1976 in the district. As indicated below temperature trend had increased throughout 41 years. This value was calculated from instat software. It was peak during the year 2016 and 2017 registering 26.00°C and 26.17°C mean annual temperature in *Wogera*woreda, which actually is aligned with the El Nino occurrences of 2015/16 in different parts of Ethiopia.

This investigation is consistence with (Weldlul, 2016), which revealed that temperatures in Ethiopia have increased resulting in high rate of Evapo-transpiration of surface water, pronounced warming has occurred in winter and spring, with the largest increases in the period March-May over Ethiopia. Further analysis was computed to check whether the trend of temperature is significant or not over 41 years. Accordingly, Mann-Kendall test was undertaken.

Table 2 Mann-Kendall annual average temperature trend test and Sen's slop estimator value of *Wegeraworeda*

Kendall's tau	1.029
Sen's slop	1.701
p-value	0.001
Alpha	0.05

As the computed p-value is less than the significance level alpha=0.05, meaning there is an increasing trend in temperature.

MONTHLY AND ANNUAL TREND OF RAINFALL OF *WEGERA* WOREDA

Table 3. Estimated Monthly non parametric results and significance test.

Month	Mann-Kendall trend test	P value	Sen's slop	Is there trend? (Level of significance, 5%)
January	-0.103	0.4	-0.027	No
February	-0.402	0.001*	-0.20 3	Yes
March	-0.321	0.006*	-1.828	Yes
April	-0.103	0.397	-0.821	No
May	-0.025	0.844	-0.496	No
June	-0.022	0.866	-0.743	No
July	0.284	0.016*	7.625	Yes
August	0.190	0.112	7.104	No
September	0.170	0.157	3.587	No
October	-0.027	0.831	-0.134	No
November	0.106	0.382	0.181	No
December	-0.039	0.754	-0.049	No

**** are 0.05 level of significance.***

The results of Mann-Kendall test for trend analysis of data are presented in table 6 above. The trend analysis has been done for all months of the year for the station under study in the district. The estimated Sen's slope has been calculated for January to December. As it can be elucidated in (table 3) above, there was a significant decreasing trend on February and March while there was a significant increasing rainfall trend over the district. On the other hand on January, April, May, June, October and December, there was a negative trend but the trend was not statistically significant. August, September and November shows statistically a non-significant increasing trend of rainfall. This result is quite significant as the months where Mann-Kendall trend analysis has shown negative trend, similar negative slope has been observed for the Sen's Slope and vice versa.

In the non-parametric Mann-Kendall test, trend of rainfall for 42 years from January to December has been calculated for each month individually together with the Sen's magnitude of slope. In the Mann-Kendall test describes the trend of the series for individual 12 months from January to December which are -0.103, -0.402, -0.321, -0.103, -0.025, -0.022, 0.284, 0.190, 0.170, -0.027, 0.106, -0.039, respectively. For July, August, September, and November there is an evidence of rising trend while test value is showing negative trend in January, February, March, April, May, June, October, and December. Thus test values for four months show a positive trend and for other eight months.

Perceived effects of climate change on the livelihoods of farming household heads

Up to 85.58% of respondents singled out crop failure as the worst immediate impact on people's livelihoods. About 64.56% of the respondents who reported that food shortage followed by water scarcity (61.56% of respondents) were found to be serious effects of climate change on *Wegera* district

Table 4 Effects of climate change on the livelihoods of smallholder

Result	***Number of farmer's***	***Percent of farmer's***
Decline in crop yield	285	85.58
Health problem	198	59.46
Loss of income	88	26.42
Food shortage	215	64.56
Death of Livestock	213	63.96
Water scarcity	205	61.56
Decline in consumption	211	63.36

Source household survey 2019

These shocks resulted in a variety of reported losses, primarily consisting of decline in crop yield, food shortage, death of Livestock, decline in consumption, and water scarcity.

In addition, the consequent reduced economic activity translated into shortage of jobs (especially casual labour, which most of the residents depended on) and hence reduced household incomes. Up to 59.46% of the respondents indicated that health problems particularly malnutrition of family members was also a serious felt effects of climate change.

Results from Focus Group Discussions (FGD) indicated that climate have serious impacts on many key livelihood factors in *Wegera* district. Climate change thus interprets into increased vulnerability of the resource poor households in the district. This predicament requires urgent attention especially in the development of alternative, viable and sustainable food security strategies.

Farmers' Adaptation Strategies Analysis

Adaptation mechanisms for the effects of climate change refers to the strategy applied by individuals, families, communities, institutions, firms and society at large or governments to cope with the negative effects of climate change (Asfaw et al., 2018). Households in *Wegera* district seven adaptation measures could be identified in the study area as farmers' responses to increased temperature, reduced rainfall and disrupted rainfall patterns.

Findings showed that used crop diversification 67.78% , growing drought resistant crops 65.47% and Planting short season variety 61.56% were identified as the best major adaptation strategies to climate change in the study area, As indicated table 5, used crop diversification is most commonly used adaptation strategies to climate change in the study area.

Table 5 Adaptations strategies in response to change in temperature and Precipitation

Result	***Number of farmer's***	***Percent of farmer's***
Planting short season variety	205	61.56
Sold livestock	134	37.22
used crop diversification	44	67.78
Soil and water conservation	111	30.83
Find off-farm jobs opportunities	98	27.22
Change planting dates	71	19.72
Growing drought resistant crops	218	65.47

Source household survey 2019

The above table describes the types of adaptation strategies employed under different climatic shocks by percentage of farmers who used the particular adaptation strategy. As elucidated from the table above, sold livestock (37.22%), Soil and water conservation (30.83%), Find off-farm jobs opportunities (27.22%), and change planting dates (19.72%) were the least adaptation strategies to climate change in the study area.

The FGD finding also revealed that, crop diversification, drought resistant crops and planting short season variety were effective strategies to mitigate the effects of climate change. When discussing about the adaptation strategies, FGD participants from *Kentefa*and*Gefualkebeles* stated the following.

> *We farmers use a variety of adaptation strategies to reduce the effects of climate change , farmers in the above stated kebele usually using crop diversification, drought resistant crops and Planting short season variety were important in time of food insecurityWe also sell cattle and chicken to buy food form the market. Find off-farm jobs opportunities also play significant role in critical times, households can search different jobs to gain money from different organizations to buy food.*

Community leaders and developmental agent from the two kebele indicated that planting new crops or new variety, Soil and water conservation, using crop diversification, and drought resistant were the best adaptation strategies. However, some farmers were not properly employed the above strategies in the study area.

Determinants of Farmers' Adaptation Choices

In this section, selected explanatory variables were used to estimate theMultinomial Logit (MNL) regression model to analyze the determinants of households' adoption choices. A MNL model was fit to estimate the effects of the hypothesized explanatory variables on the probabilities of adoption.

Finally, a set of 8 explanatory variables were included in the MNL analysis. These variables were selected on the basis of theoretical explanations, personal observations and the results of the survey studies.

To determine the best subset of explanatory variables that are good predictors of the dependent variable, the MNL regressions were estimated using the method of maximum likelihood estimation, which is available in statistical software program (SPSS version 20)

The following summarizes results from the MNL analysis:

Education level of the farmers increases the probability of uptake of adaption options climate change. As can be observed in Table 6, education level significantly increases crop diversification and soil and water conservation as an adaptation method in the study area. (Kelelew et al., n.d.) , Also suggested that literacy status of farm households' increases awareness about the consequences of climate change on productivity and benefit of crop production and soil and water conservation practices to reduce impacted of climate change

Farmer experience increases the probability of uptake of planting short season variety and changingplanting dates as adaptation measures. Experienced farmers are more likely to adopt changing planting dates and planting short season variety in the study area. These results confirm the findings of(Abid, Scheffran, Schneider, & Ashfaq, 2015),The import is that highly experienced farmers are likely to have more information and knowledge on changes in climatic conditions. Experienced farmers are usually leaders and progressive farmers in rural communities and these can be targeted in promoting adaptation management to other farmers who do not have such experience and are not yet adapting to changing climatic conditions.

Farmers who have significant extension contacts have better chances to be aware of changing climatic conditions and also of the various management practices that they can use to adapt to changes in climatic conditions.

Access to credit:As expected, the results show that having access to credit increases the propensity of farmers to adapt to climate change. Farmers who have access to credit are more likely to adopt planting short season variety

This finding corroborates with the findings of (Kumar & Sidana, 2018), Access to credit service is an important factor to narrow the financial gap of the farmers so that they could purchase the required farm inputs and technologies that are useful for improving agricultural production and also to carry out income generating activities other than farming

Access to extension services: significantly increases the probability of taking up adaptation options in the study area. Indeed, farmers who have access to extension services are more likely to adopt growing drought resistant crops. These results confirm the findings of(Asrat & Simane, 2018), Extension services provide an important source of information on climate change as well as agricultural production and management practices. Farmers who have significant extension contacts have better chances to be aware of changing climatic conditions and also of the various management practices that they can use to adapt to changes in climatic conditions.

Access to climate information: As expected, access to information on climate change has a significant and positive impact on farmers' adopting changing planting dates and planting short season varieties these result also confirm the findings of(Alem, Kibebew, Jemma, Muktar, & Yosef, 2016)

Amazingly, farm land and access to adequate waterhave decreased the farmers' tendency to adopt planting short season variety, crop diversification, growing drought resistant crops and changing planting dates as adaptation measures to climate change in the study area.

Table 6Multinomial logit model

	Coefficient (in log-odds unit)						
Variables	Planting short season variety	Sold livestock	used crop diversification	Soil and water conservation	Find off-farm jobs opportunities	Change planting dates	Growing drought resistant crops
farming	0.08**	0.12	0.08**	0.02	0.04	0.12**	-0.85
experience	(2.31)	(0.79)	(1.82)	(0.52)	(0.64)	(2.7)	(-0.12}
Level of	0.13**	-0.18	-0.05	0.07**	0.12**	-0.02	0.78
Education	(2.31)	(-1.09)	-(0.61)	(2.50)	(0.86)	(-0.46)	(1.14)

Access to extension services	-1.98 (-4.62)	0.16 (0.23)	0.94 (1.61)	-0.56 (-0.54)	0.53 (0.57)	-2.75 (-6.44)	0.16*** (0.30)
access to credit	1.62** 2.62	1.67 1.56	0.42 0.60	0.94 (1.33)	2.42 2.49	-15.02 (-0.00)	2.90 (1.18)
Access to agricultural technology	1.83 (0.89)	-0.26 (-0.40)	1.01 (1.83)	0.82 (0.80)	-0.50 (-0.54)	0.81 (1.71)	1.81 (0.87)
Farm land size	-1.02** (-1.86)	16.27 (0.02)	-2.33 (-4.08)	-0.23 (-0.18)	-0.53 (-0.56)	-2.31** (-4.08)	-18.35 (-0.02)
Access to adequate water	0.78 (1.48)	0.78 (1.23)	-2.57** (-2.23)	-15.89 (-0.01)	0.89 (1.08)	-1.55* (-2.37)	-2.24** (-4.37)
Access to climate information	0.07** (2.23)	0.69 (1.22)	2.42 (5.01)	1.46 (2.46)	-14.23 (-0.03)	0.18*** (0.25)	2.49 (5.12)
Constant	-2.60** (-2.39)	-0.17 (-0.06)	-2.83** (-2.45)	0.09 (0.04)	-2.53** (-2.63)	-1.69** (-1.75)	-19.39 (-0.04)
Observations	333	333	333	333	333	333	333

*** p<0.01, ** p<0.05, * p<0.1

Z-statistics in parentheses

CONCLUSIONS AND POLICY RECOMMENDATIONS

The study sought to assessFarmers' perception of climate change and determinants for adaptation strategiesin*Wogera* district central Gondar, Ethiopia **.**Climatic data of the study areas as depicted by trend analysis of both temperature and rainfall indicated that temperature is increasing while precipitation trends signified the decrement of average annual rainfall. These led to the occurrence of recurrent drought in the study areas and the prevalence of high temperature. Though the livelihood small holder farmers put at jeopardize in the study areas, unless seek for other alternative options to mitigate the impacts of climate change.

The study uses the multinomial logit (MNL) model to assess the factors influencing farmers' choices of climate change and variability adaptation methods. The model, results highlighted that education level, farming experience, access to extension services, access to climate informationand access to credit are the factors that enhance farmers' adaptive capacity to climate change and variability.

This study demonstrates the importance of government policies and strategic investment plans, ensure that farmers have access to affordable credit schemes to increase their ability and flexibility to adopt adaptation measures in response to the forecasted climate conditions.

Moreover, given that extension services are inadequate in the study area, improving the knowledge and skills of extension service personnel and making the extension services more accessible to farmers appear to be some of the key elements of a fruitful adaptation program.

It is also important to enhance research and development and introduce new crops/varieties that will give farmers a hand in adapting to harsh climatic conditions. Finally, investment in education systems in the rural areas can be underlined as a policy option regarding reduction of the adverse impacts of climate change in the study area.

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