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Analysis of Climate Variability and Adaptive Strategies of Rural Household: The Case of Abobo District and Itang Special Districts, Gambella Region State, Ethiopia

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Authors' contributions

This work was carried out in collaboration between both authors. Author MD designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author PKD managed the analyses of the study. Both authors read and approved the final manuscript.

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ABSTRACT

Many low-income regions are largely affected by climate change impacts as a result of their relatively low adaptive capacity as pointed out by IPCC. Particularly, the change of climate has adverse implications to the Ethiopian economy with connection to different climatic parameters. The main objective of this study was to examine climate variability and its effect on rural households in Abobo District and Itang Special District. Both primary and secondary data were collected during the study. For this study, 240 HHs were interviewed from both Abobo District and Itang Special District while FDGs and KII were collected qualitatively. Relevant secondary data were also obtained from the National Meteorology Agency of Gambella station. Descriptive statistics were used to analyze the characteristics of sample households and farmers' perception of climate variability. Moreover, multivariate probit model was employed to identify the determinants of smallholder farmers' choice of adaptation strategies to climate variability. The result indicated that the major adaptation strategies applied by smallholder farmers in the study area including the use of improved crop

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varieties, adjusting the planting date, planting trees, crop diversification and using drought-resistant crop. Multivariate Probit model result shows that age, education, farm income, extension contact and access to credit significantly affect HHs choose of improved verity as adoption strategy; total land hold, farm income and extension contact significantly affect HHs choose of adjusting planting date tree as adoption strategy; farm income is the only factor significantly affect HHs choose of planting tree as adoption strategy; age, education, farm income and access to credit significantly affect HHs choose of crop diversification as adoption strategy and education and access to credit significantly affect HHs choose of improved verity as adoption strategy.

Keywords: Climate variability; rural household; adaptation strategies; Abobo District; Itang Special District.

1. INTRODUCTION

1.1 Back Ground and Statement of Problem

There is a worldwide consensus that global warming is a real, rapidly advancing and widespread threat facing humanity this century. Scientists have presented evidence and tested models to substantiate this truly alarming fact [1,2,3]. The evidence confirms that man-made factors such as deforestation, agriculture, industries, automobiles, and the burning of fossil fuels, are contributing to Greenhouse Gas (GHG) emission, a major cause of global warming [1]. The warming has manifold impacts on ecosystems and biological behaviours. Some widely discussed impacts include snow melting and glacier retreat, drought and desertification, flooding, frequent fire, sea-level rise, species shifts, and heightened diseases incidence. These ecological and biological responses can consequently lead to serious consequences for human wellbeing [4,5].

IPPC, [6] point out that climate variability will certainly affect the future sustainable development of much of our planet's resources such as those relating to biodiversity, water, forests, land and oceans as well as in relation to various sartorial activities like agriculture, forestry and biodiversity.

The climate of the Earth has never been stable, least of all during the history and evolution of life on Earth. Recent glacial periods, for example, have been (globally) 4°–5°C cooler than now and some interglacials have been (perhaps) 1°–2°C warmer. These prehistoric changes in climate were clearly natural in origin and occurred on a planet inhabited by primitive societies with far smaller populations than at present. Indeed, the regularity of the diurnal and seasonal rhythms of our planet has always been overlain by inter-annual, multi-decadal and millennial variations in climate, over whatever timescale climate is defined. Ecosystems and species have moved, often freely, in response to such past changes and have evolved within this climatic history [7].

Some researchers have documented that climate-related impact is stronger in Africa, where agriculture is important for the daily subsistence, and where adaptive capacity is low. According to the [8], average annual rainfall trends remained more or less constant between 1951 and 2006, whereas seasonal rainfall exhibited high variability [9] there is a considerable decline in rainfall from March-September in north and southeast and southwestern parts of Ethiopia after 1997. In particular, rainfall amounts have significantly decreased during the *belg* season in the east and southeast.

Awetahegn [9] in Tigray region found The mean minimum temperature ranges between 10.2°C and 12.6°C, while, the mean maximum temperature varies between 22.3°C and 26.7°C From the analysis the monthly coefficient of variation (CV%) for both maximum and minimum temperature ranging from (6.9% in Oct) to (18.7% in Dec) for the average monthly rainfall ranging from 4.9% to 26% of coefficient of variation (1995-2014). According to analysis of the historical climate data and its models in North Central Ethiopia there has been an increasing trend of maximum and minimum temperature and a general tendency of decreasing rainfall. The mean average change of annual temperature indicates significant variations of temperature observations approximately by 1.5°C [10].

USAID [11] technical report on climate variability and change in Ethiopia reported that maximum temperatures during *kiremt*season vary between

0.4-0.6 OC/decade in Amhara, Oromia, Afar and Tigray region. *Belg*season temperatures showing more rapid increases (> 0.6 OC/decade) in all regions. An increasing trend in annual maximum temperature by 0.44 OC, whereas minimum temperature decreased by -0.12OC per year at Butajira station [12]. Analysis of rainfall and temperature trend is helpful in rain-fed agriculture to devise site-specific adaptation responses against to climate risks.

In recent time, increasing climate variabilities such as rising temperature and erratic rainfall is critical problem of crop production. A recent mapping on vulnerability and poverty in Africa puts Ethiopia as one of the most vulnerable countries to climate change and the least capacity to respond (Yosuf et al. 2008). According to NMSA [13], recurrent drought, famine and food insecurities are the main problems that affect millions of people in the country almost every year. These all problems were mostly developed due to the communities have less awareness about climate variability and its effects.

Generally, like other parts of the country, the livelihoods of the rural communities of Abobo district and Itang special district is based agriculture. On the other hand, the study area is characterized by erratic rainfall and relatively higher temperature. Also, there is a fragmented and maladaptive practice. As a result, the already affected communities are tending to get worse. Therefore, this study was designed to examine climate variability and its effect on rural households.

Now a day, in certain area, communities couldn't get the right information of climate that enable them strong defender of climate related hazards, specially, lacks the past-present-future climate prediction have high effects on daily activities. However, [14] reflected that, assessing the characteristics of climate variables in past together with households/farmers' perception is crucial to develop suitable adaptation strategies against climate change. In recent times, both decline in precipitation and increase in temperature has been expanding in Gambella region.

The general objective of the study was to examine climate variability and its impact on rural households (HH) in Abobo district and Itang special district, Gambella National Regional State, Ethiopia.

This study specifically focused on the assessment of climate variability,rural HHs perceptions to climate variability and determinants of rural HHs choice of adaptation strategies to climate variability.

2. RESEARCH METHEDOLOGY

2.1 Map of Study Area

This study done in *Itang* special Woreda and *Abobo* Woreda. *Itang* Woreda is considered as special Woreda administrative subdivision. It is bordered on south and southeast by *Anuak* zone on the west by the Nuer zone, on the northwest by South Sudan and on the north by the Oromia Region. The area is specially, dependent on livestock.

In others ways, *Abobo* Woreda is one of the selected areas for the study. It is part of Anuak zone. It is bordered on south east by *Mezhenger* zone,on south by Gog on south west by Jor on the north west by *Itang* special district, on the north by Gambela zuria and on the north east by Oromia region.

2.2 Data Type and Data Source

Data were collected from both primary and secondary sources. The primary data was collected through questionnaire, key informants and focused group discussion. Group discussion was used to get more information on relevant or similar ideas raised and to get concentrated points at the end. Focused group discussion helps to generate data on group dynamics.

Secondary data was collected using available sources of information such as published and unpublished documents. This includes data from government offices, metrological agency. Rainfall and temperature data was obtained from Gambella National Meteorological Agency for the periods of 1982-2017.

2.3 Sample Size and Sampling Technique

Determining appropriate and representative sample size is critically important to include all the parameters of the populations. In study area, Abobo district, there are about 21 rural kebeles and in Itang special district, there are 23 rural kebeles. Multistage sampling technique was employed to select sample kebeles from each district. At first stages, using random sampling

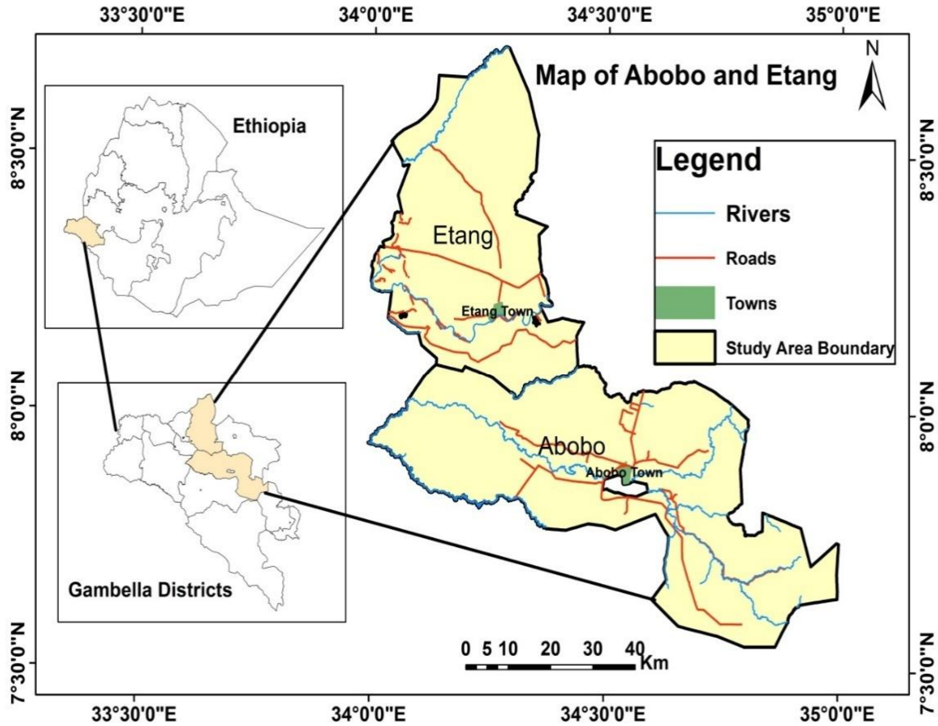

Fig. 1. Map of study area

Source: Developed by author based Ethio GIS data using Arc Map 10.2

technique kebeles was selected (three kebeles from each district). At the second stage, 118 HH samples was selected from Abobo and 122 from Itang special Woreda based on Probability Proportional to Size (PPS) using Yemane [15] formula.

$$n = \frac{N}{1 + N(e)^2} \qquad (1)$$

Where n is the sample size, N is the total HH inItang specialdistrict (7675) and Abobodistricts (2933), and e is the level of precision (9%).

2.4 Data Analysis

2.4.1 Descriptive statistics

Various methods of data analysis were employed in the study. For the data was obtained from the selected areas' HHs were presented using figure, percentage and frequencies. Accordingly, analysis of the rainfall and temperature data was involved characterizing long-term mean values and calculation of indices of variability and trends at monthly time steps. The coefficient of variation was used as statistical descriptors of rainfall and temperature variability.

2.4.2 Econometric model

Econometric model was applied for identifying the determinants of rural HH choice of adaptation strategies to climate variability. Among different econometric models, Multinomial Logit and multivariate Probit model are more used in the multiple choices. The multinomial logit model considers the Independence of Irrelevant Alternatives (IIA) assumption but the multivariate Probit model does not require the Independence Irrelevant Alternatives (IIA). A shortcoming of most of the previous studies on modeling choice of climate change adaptation strategies is that they do not consider the possible inter-relationships between the various strategies. This study employed Multivariate Probit Model (MVP) to identify the determinants of smallholder farmers' choice of adaptation strategies by putting the k binary dependent variable as given below

$$Y^*_{hpj} = X^*_{hpj}B_j + U_{hpj} where j = 1,2,3 \ldots \ldots \ldots \ldots k$$

And

$$Y_{hpj} = \begin{cases} 1 \; if Y^*_{hpj} > 0 \\ 0 \; otherwise \end{cases}$$

Where j= j[th] adaptation strategy to climate change

X_{hpj}^{*} = is vector of explanatory variables.

B_j = is vector of parameter to be predicted.

U_{hpj} = is the random error term or stochastic variables as multivariate normal distribution with zero mean and unitary variance.

Y_{hpj}^{*}=variables which capture the demand related with the j[th] choice of adaptation strategies to climate change.

Y_{hpj} = is indicate the HH use or not use the particular adaptation strategy. As a result of, adoption of different adaptation strategies is possible, the error terms in equation are assumed to jointly follow a multivariate normal distribution, with zero conditional mean and variance normalized to unity. The off-diagonal elements in the covariance matrix represent the unobserved correlation between the stochastic component of thej^{th} and k^{th} type of adaptation strategies. This assumption means that equation gives a multivariate probit model that jointly represents decision to adopt a particular adaptation strategy. This model was applied in [16], findings on the analysis of determinants of farm level adaptation measures to climate change in South Africa. Similarly this research was employed MVP model mainly to identify the determinants of rural HHs choice of adaptation strategies to climate variability.

3. RESULTS AND DISCUSSION

3.1 Description of Rainfall and Temperature

The analyzed long historical data of rainfall revealed that, Abobodistrict have gotten the 827 and 1617 mm of maximum and minimum of total annual rainfall in observed years. On average, 1199.4 mm of total rainfall has recorded in the area in similar time pattern. Rainfall distribution observed in studied area shows that less rainfall distribution which estimated to CV=15.3%. Like in Abobo district, Itang district has addressed different rainfall and temperature distribution in taking time. The minimum and maximum total annual rainfall were 719 mm and 1936 mm with mean 1211.9 mm and SD249.7 mm. The analyzed long historical data authenticated that, the rainfall of the area was moderately variable showing 20.60% of coefficient variation. These results were not in line with the mean annual rainfall reported by the World Bank [17], which was 2000 mm in the southwestern highlands of Ethiopia.

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The annual total rainfalls have increased by the of factor rate 1.060 mm/year in Abobo and 8.932 mm/year in Itang. According to Hulme et al. [18] and IPCC [2], East Africa rainfall shows an increasing trend. In contrast, [19] had investigated the spatio-temporal variability of annual and seasonal rainfall over Ethiopia and reported a decreasing trend of annual rainfall in northern, northwestern and western parts of the country.

In the Abobo district, the maximum and minimum values of minimum temperature were 17.3°C and 22.3°C respectively. But, the mean and Standard deviation recorded were19.5°C and 1.10°C in order. The coefficient variation (CV=5.7%) of the analyzed data revealed that, the minimum temperature of the area was less variable or more reliable. However, the minimum and maximum values of the maximum temperature of the area ranged from 32°C to 37.2°C with mean=34.7°C and standard deviation =1.1°C. Like the minimum temperature, the analyzed maximum temperature data has showed that, the distribution of temperature was not more sparse or more reliable (CV=2.8%).

Accordingly, the minimum and maximum of minimum temperature recorded over Itang in taken years were 18.2°C and 22.2°C, respectively. Averagely, recorded minimum temperature was 19.67°C with SD =0.9°C showing less variation (CV=4.5%) or more reliable which indicates that the distribution of minimum temperature over the area was more consistent. On the other hands, minimum and maximum of maximum analyzed temperature were 31.7°C and 38.9°C in order. And also, the revealed mean and SD were 34.6°C 1.5°C respectively. Its distribution was more reliable with CV=4.4%. On the other hands, the annual

Table 1. Summary description of rainfall and temperature over meteorological data at Abobo from 1982-2018 and Itang from 1982-2016

Param	Abobo			Itang		
	Rf	Max	Min	Rf	Max	min
Mini	827	32	17.3	719	33.1	18.2
Max	1617	37.2	22.3	1936	34.3	22.2
Mean	1199.4	34.7	19.5	1211.9	33.7	19.7
Sd	183.74	1.1	1.1026	249.7	0.4	0.9
Cv(%)	15.3	2.8	5.7	20.6	1.1	4.5
Trend(°C/year	1181	34.72	19.95	1064	20.05	33.87
Slope(rate/year)	1.06	-0.001	-0.023	8.932	-0.022	-0.011

Source: Own data computation (2019)

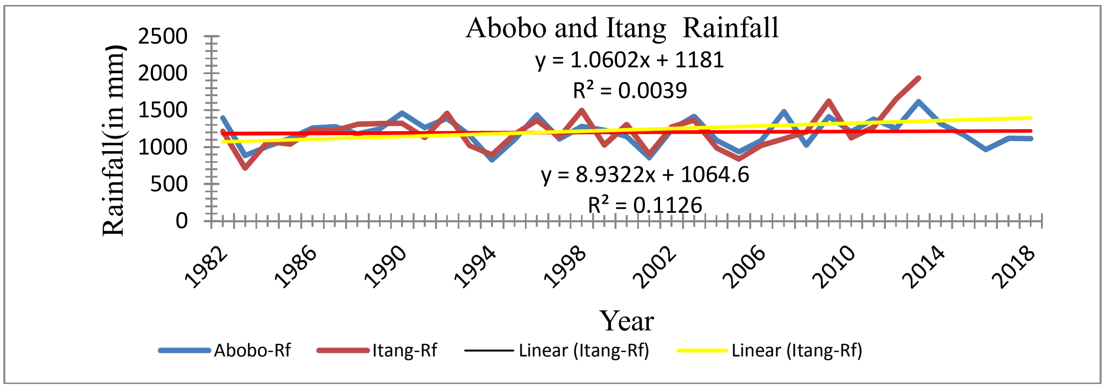

Fig. 2. Distribution of rainfall in Abobo and Itang from 1982-2018

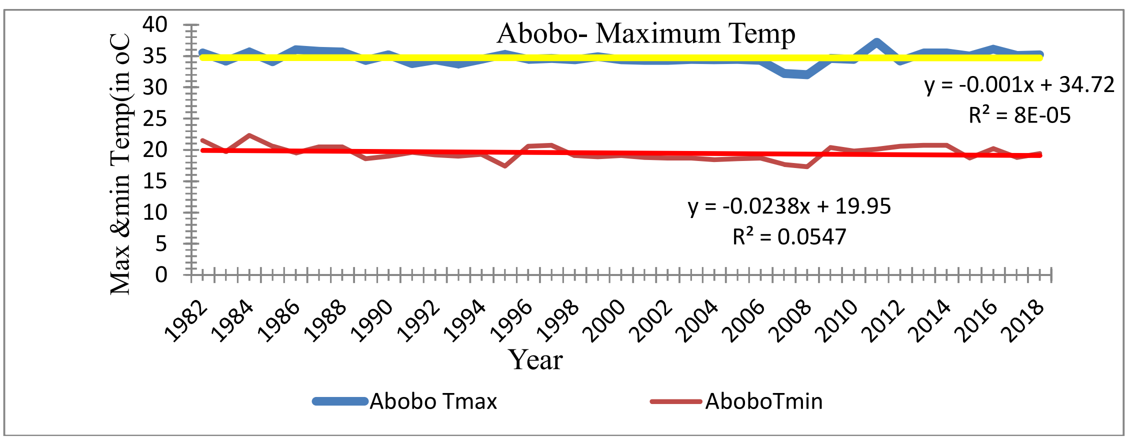

Fig. 3. Distribution of maximum and minimum temperature in Abobo from 1982-2018

mean maximum and minimum temperature of Abobo were decreased by the rate of -0.001°C and -0.023°C per year, respectively. The result is inconsistent to the NMSA [8], in which the average annual minimum temperature over the country has increased by about 0.37°C.

According to National Meteorological Services of Ethiopia 2007, indicate that the average minimum and maximum temperatures have been increasing by about 0.25°C and 0.1°C, respectively over the past decade whereas the rainfall has been characterized by a very high level of variability over the past 50 years.

3.2 Perceptions of House Hold on Climate Variability in Study Area

Table 2 shows the perception of respondents with regard to rainfall patterns in the Abobo and

Itang districts. The surveys show that, about 33.1% of the respondents reported that rainfall of the Abobo has been decreasing whereas over 54% of respondents perceived an increasing rainfall. Similarly, the analyzed long historical climatic data obtained from meteorological station of Abobo in (1982-2018) have revealed, annual rainfall total increased by the factors of 1.060 mm/year (Table 3, Table 2 and Fig. 2). However, 12.7% of the respondents couldn't identify the variability of rainfall.

On the other hands, the surveys in Itang have shown, over 41% of the respondents responded that the rainfall has been increasing whereas 35.2% said that, rainfall has been decreasing. But, 23% of the respondents didn't identify. These perceptions of HHs have agreed with the results obtained from data of meteorological stations (Table 3, Table 2 and Fig. 2) confirmed that, annual total rainfall of the area increased by the factor rate of 8.932mm/year in (1982-2016).

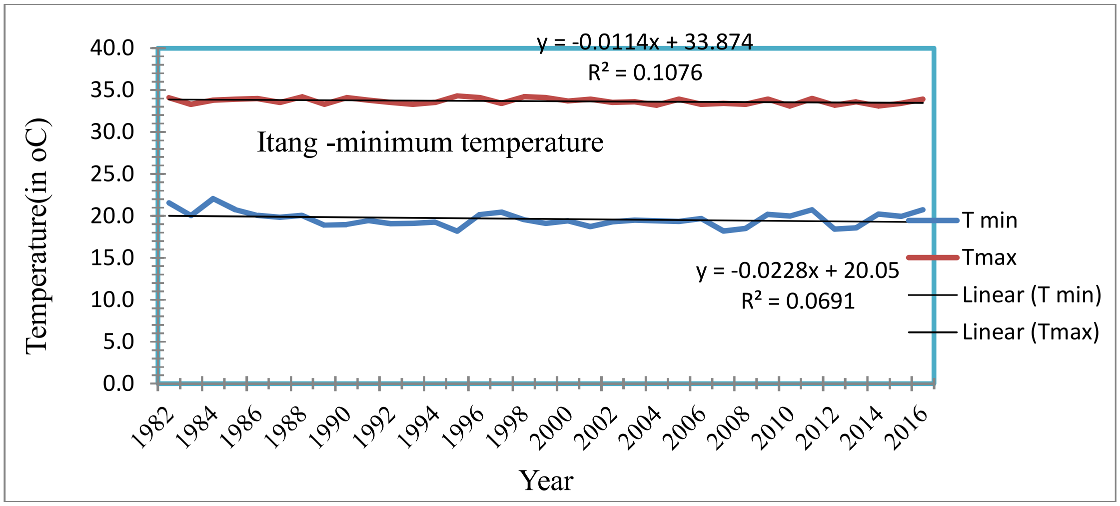

Fig. 4. Distribution of maximum and minimum temperature in Itang from 1982-2016

Table 2. Summary description of rainfall and temperature over meteorological dataat Abobofrom 1982-2018 and Itang from 1982-20162

Param	Abobo			Itang		
	Rf	**Max**	**Min**	**Rf**	**Max**	**min**
Mini	827	32	17.3	719	33.1	18.2
Max	1617	37.2	22.3	1936	34.3	22.2
Mean	1199.4	34.7	19.5	1211.9	33.7	19.7
Sd	183.74	1.1	1.1026	249.7	0.4	0.9
Cv(%)	15.3	2.8	5.7	20.6	1.1	4.5
Trend(^{o}C/year)	1181	34.72	19.95	1064	20.05	33.87
Slope(rate/year)	1.06	-0.001	-0.023	8.932	-0.022	-0.011

Source: own data computation (2019)

Table 3. Distribution of respondents on rainfall patterns

What was the rainfall pattern in past year in your area?	Respondents			
	Abobo		**Abobo**	
	N	**%**	**N**	**%**
Increased	39	33.1	51	41.8
Decreased	64	54.2	43	35.2
I don't know	15	12.7	28	23
Total	118	100	122	100

Source: own data computation (2019)

Table 4. Distribution of respondents on temperature patterns

What was the temperature pattern in past year in your area?	Respondents			
	Abobo		Itang	
	N	%	N	%
Increased	62	52.5	66	54.1
Decreased	39	33.1	41	33.6
I don't know	17	14.4	15	12.3

Source: own data computation (2019)

Table 5. Multivariate probit results for HHs' climate change adaptation choice

Variable	Improved crop variety		Adjusting planting date		Planting tree		Crop diversification		Drought resistance crop	
	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE
AGEHH	.013*	.007	-.010	0.007	-.004	.008	.023***	.007	-.003	.008
SEXHH	.0314	.215	-.182	.212	.161	.231	-.137	.206	-.319	.277
EDNHH	.107**	.033	-.027	.031	-.032	.034	.076**	.030	.074*	.041
TLHOLD	-.043	.097	.273***	.103	.071	.109	-.066	.090	.054	.115
FARMINC	.000**	.000	-.000***	.000	-.000*	.000	.000*	.000	.000	.000
LSHOLD	.011	.28	.025	.029	-.008	.030	.032	.026	-.019	.032
NONFINC	-.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
MEXTCON	.092*	.033	.073**	.034	-.022	.029	.023	.028	-.005	.035
CR	.430**	.188	-.145	.183	-.188	.211	.461**	.178	.630**	.247
CCRTR	.203	.195	.059	.188	-.281	.211	.110	.184	.262	.236
Cons	-1.08***	.398	.538	.384	1.509***	.455	-1.347 ***	.391	1.527***	.484
Predicted probability	68.7		61.3		81.6		59.2		87.1	
Multivariate probit (MSL, # draws = 5) Wald chi^2 (50) = 111.73 Log likelihood = 598.98172 Prob > chi^2 = 0.0000							Number of obs = 240			

Table 4 shows that the majority of farmers interviewed perceived a long-terms change in temperature in the area. In Abobo district, over 52.5% of the respondents perceived an increase whereas about 33.1% a decreasing temperature. About 14.4 of the interviewed HHs didn't perceive the temperature of their area. Similarly, in Itang, over 54% of the respondents responded that temperature of the area has been increasing from past to now. However, 33.6% of them supported the ideas that temperature of the area has been decreasing whereas 12.3% didn't support any.

Consistently, the analyzed data have authenticated decreasing of annual mean minimum and maximum temperatures at Abobo district by rate of-0.001°C/year and -0.023°C/year, respectively over thirty seven years (1982-2018). Similarly, the annual mean minimum and maximum temperature were decreased at Itang district by the rate of-0.022°C/year and -0.011°C/year respectively over thirty five years (9182-2016).

Moreover, Schwartz [20] pointed that people believe climate may change owing to fresh climate experiences, such as the recent 2015/2016 El Niño events prior to the data collection period may contribute to their perception in the study are context.

3.3 Determinants of Smallholder Farmers' Choice of Adaptation Strategies

In order to reduce the impacts climate variability, farmers in study area were employed improved varieties of crops, adjusting planting date, crop diversification, planting tree and drought resistance crop as climate variability adaptation strategies. These adaptation methods were mostly applied to safeguard farmers from losses that would appear as a result of changes in climatic variation like temperature and rainfall irregularity.

Table 6. Probability results of success and failure

Joint probability of success								**18%**
Joint probability of failure								**0.06%**
/	a	t	r	h	o	2	1	-.067
/	a	t	r	h	o	3	1	.024
/	a	t	r	h	o	4	1	.303***
/	a	t	r	h	o	5	1	-.330**
/	a	t	r	h	o	3	2	.158
/	a	t	r	h	o	4	2	-.162
/	a	t	r	h	o	5	2	-.057
/	a	t	r	h	o	4	3	.214*
/	a	t	r	h	o	5	3	-.061
/	a	t	r	h	o	5	4	-.065
r	h		o		2		1	-.067
r	h		o		3		1	.024
r	h		o		4		1	.295***
r	h		o		5		1	-.319**
r	h		o		3		2	.157
r	h		o		4		2	-.161
r	h		o		5		2	-.057
r	h		o		4		3	.210*
r	h		o		5		3	-.060
r	h		o		5		4	-.065
Likelihood ratio test of rho21 = rho31 = rho41 = rho51 = rho32 = rho42 = rho52 = rho43 = rho53 = rho54 = 0: chi2(10) = 22.0875 Prob > chi2 = 0.0147								

****, ** and * indicate significant at 1%, 5% and 10% probability level, respectively*

The analyses in the study identified the important determinants of adoption of various adaptation options (strategies) using a multivariate probit model to provide policy information depending on the model results to upgrade the farmers in using of different adaptation strategies. Demographic, socio-economic and institutional characteristics were considered to assess whether they have influence on HHs' choices of the adaptation strategies or not. Results from the multivariate probit model of determinants of choice adaptation strategies using data from a cross-sectional survey of 240 sample HHs were presented below.

The model fits the data reasonably because of Wald test (Wald chi2 (50) = 111.73, p=0.0000) is significant at 1%, level, which indicates that the subset of coefficients of the model is jointly significant and that the explanatory power of the factors included in the model is satisfactory; thus, the MVP model fits the data reasonably well. Likewise, the model is significant because the null that choice decision of the five adaptation strategies is independent was rejected at 5% significance level. The likelihood ratio test of the model is (chi2(10) = 22.0875 Prob>chi2 = 0.0147) indicates the null that the independence between adaptation choice is rejected at 5% significance level is statistically significant and there are significant joint correlations for 3 of the 10 cases estimated coefficients across the equations in the models. Indicating that, the correctness of the multivariate probit specification and choice of climate change adaptation strategies are not mutually independent.

The result of multivariate probit model shows that the likelihood of HHs to adopt, planting tree, drought resistance crop, improved crop varieties, adjust planting date, and use crop diversification were 81.6%, 87.1%, 68.7%, 61.3% and 59.2% respectively. The likelihood of HHs to jointly choose the five adaptation strategies simultaneously is 18%, while their failure to jointly choose is 0.06%.

The MVP model estimated results in Table 5, shown that the likelihood function of climate variability adaptive strategies was highly significant at 1% level significance level (Log likelihood = 598.98172 Prob > chi2 = 0.0000) indicating a strong explanatory power of independent variables to explain factors determining climate variability adaptive strategies of rural HHs (goodness of fit of the model).

Age of household head (AGEHH): Influenced the likelihood of choosing improved crop variety and crop diversification positively and significantly at 10% and at 1% significant level respectively. From this, as age of HH head increase, using of improved crop variety and crop diversification increase which contribute HHs vulnerability to climate change. But some empirical studies result is controversial with our outcome. Empirical studies by Arega et al. [21] and Gebreyesus [22], shows that age of the HH head negatively related to farmers decision to diversify to non-farm and off-farm activities.

Education (EDNHH): Education influenced the likelihood of choosing improved crop variety and crop diversification positively and significantly at 5% and drought crop resistance at 1% significant level. Because as the HH farmers educated their using of improved crop variety and crop diversification and using drought resistance crop also increase. As a result of this, the production and productivity of farmers would be increased. Different writers found that educational status increases the awareness of farmer about the consequence of climate variation on productivity. It can be concluded that farmers with more years of schooling are more likely to adapt to climate variability adaptation strategies as compared to the farmers with little or no education. From this study, farmers with more years of schooling are more likely to choose improved crop variety and adjusting planting date as adaptation measure to climate change.

Monthly Extension contact (MEXTCON): Extension contact has a positive and significant effect on using improved crop variety and adjusting planting date at 10% and 5% significant level, respectively as adaptation choice to climate variability. Having access to extension contact increases the probability of using improved crop variety. Extension agents are give information on farming practice. Specifically, they are an important source of information on agronomic practices as well as on climate. Availability of better climate and agricultural information helps farmers make comparative decisions among alternative crop management practices and hence choose the ones that enable them to cope better with changes in climate [23].

Farm income (FARMINC): The farm income was influenced positive and significantly the likelihood of choice of improved crop varieties and planting tree at 5% and 10% significant level respectively. This could be clear because use of improved crop varieties requires financial resources to purchase improved seeds and hence increased income would encourage the investment capacity. But it was negatively influenced with adjusting planting date and crop diversification. Because farmers those have more and more farm income got to investment.

Access to Credit (CR): Credit was positively and significantly influenced the likelihood of choosing of crop diversification and improved crop variety at 5% significant level as adaptation measures in order to reduce the negative effect of climate change. Access to affordable credit increases financial resources of farmers and ability to buy crop variety and other inputs. The result is in line with finding of Lemmi [24] indicate climate change adaptation is costly and require financial capacity and lack of money hinders farmers from getting the necessary resources and technologies which assist to adapt to climate change.

Total Land holding (TLHOLD): The land holding of the HHs has a positive impact on use of adjusting planting date at 1% significant level as adaptation strategies. Farmers those have more land is more use adjusting planting date. Also the possible reason could be if the farmers have more land holding they can benefit from the economic scale of it as compared with those who have small land holding.

4. CONCLUSION AND RECOMMMENDATIONS

4.1 Conclusion and Recommendations

Different adaptation options are employed by smallholder farmers in response to climate variability and change in the study area. The main adaptation strategies can be broadly categorized to include planting tree, improved crop variety, adjusting planting period, crop diversification and drought resistance crop. It is learned that adoption of these adaptation options tends to reduce a high production risk imposed by climate variability and change. This indicates that these adaptation options provide a venue to reduce sensitivity and increase the adaptive capacity of smallholder farmers that latter improve their livelihoods and ensure food security.

The study found that access to credit allows HHs to adopt improved crop variety, crop diversification and drought resistance crop. This implies that credit market imperfection can create a barrier for the capital-constrained farm HHs to participate in different adaptation strategies.

The study further reveals that HH characteristics such as education status of the HH heads which could be enhanced through policy intervention have a significant impact on adaptation to climate change usingadopt improved crop variety, crop diversification and drought resistance crop.

The study found that age, education, farm income, extension contact and access to credit significantly affect HHs choose of improved verity as adoption strategy; total land hold, farm income and extension contact significantly affect HHs choose of adjusting planting date tree as adoption strategy; farm income is the only factor significantly affect HHs choose of planting tree as adoption strategy; age, education, farm income, and access to credit significantly affect HHs choose of crop diversification as adoption strategy, and education and access to credit significantly affect HHs choose of improved verity as adoption strategy.

A strong institutional environment to support on adaptation strategies with a focus on farmer-led participation and farmers' livelihood-based plan needed. It is imperative to implement and/or broaden policies that seek to directly or indirectly secure farmers' income and contribute for environment such as crop subsidies for environment-based activities, access to credit and other incentives that motivate farmers to adopt improved crop varieties. There is the need to invest in intermediate technology that addresses challenges hindering the adoption of strategies such as efficient irrigation. Local knowledge should form the basis for the formulation and introduction of adaptation and mitigation activities and climate advocacy in the rural communities. This knowledge base is critical in determining how realistic adaptation practices are and the willingness of local farmers to adopt them in order to adapt to changing climatic conditions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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