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The Impact of Climate Change on Small Holder Farmers in case of Lay-Gayint District, South Gonder Zone, Ethiopia

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Abstract Climate-change adversely affects agricultural production, increase poverty, food insecurity, andsustainable-development. The objective of this study was to evaluate the impact of climate change onagriculture and livelihood of smallholder farmers. This study was conducted in Lay Gaynt Districtduring the 2016/17. Primary and secondary data were collected through semi-structuredquestionnaires, interview of respondents, focus group discussion, key informant interviews andMeteorological-Data. Three kebele were selected based on AEZ, 180 sampling household wererandomly selected. Data were analyzed using STATA and Microsoft-Excel. The results of the studyshow that, there was empirical evidence of annual and maximum average annual rainfall isdecreasing the rate of 17.21mm and 7.499mm per year respectively for the last twenty-five years.The result also reveals that extreme weather change particularly have negative on agriculturalproduction. The result confirms impacts of climate change on floods, heavy rains, intensity heatwaves, drought, storm and landslides 30%, 18%, 26%, 11%, 5%, 7.5% respectively. Most frequentlyweather hazards (39.65%), had damaged agricultural crop loss, diseases occurrences that affectlivelihoods of small holder farmer. Multinomial-Logit-Model showed that gender of household head,age of HH, farm experience, farm income, farm size, livestock ownership, extension services,livestock production were statistically significant with the impact of climate change. Samplehouseholds were identified lack of basic assets; market dependence food consumption and seasonalfood shortage caused chronic food insecure. However different problem, poverty, water and landscarcity, lack of information about weather forecast, forage feed scarcity, lack of agriculturaltechnologies were major constraints. Hence to solve the above problem it is recommended that thegovernment should facilitate capacity building training; creates awareness, training and weatherinformation local population important for reduced impact climate-changes on agricultureproduction. The government support should improve education access and timely agro weatherinformation.

Keywords: 1. Climate change 2. Multinomial logit model 3. Lay-Gayint District

Back ground and Justification

Climate refers to the average weather and represents the state of the climate system over a given time period. Climate and climate change will certainly have an effect on 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 [1] .The has stated that as a result of climate change least developed countries including Ethiopiawillexperiencearrange ofadverseimpacts[2,3].In the study area Lay-Gayint District the agriculture is characterized by extreme dependence on rainfall, low use of modern agricultural inputs and low output levels.More than 75%of livelihood is dependent on rain fed agriculture that rendersthemveryvulnerabletoclimatevariabilityandchange [4].The climate of Lay-Gayint Districtcharacterized by high variability annually and seasonal distributions of precipitation are varying and difficult to predict. According to Lay-Gayint District Rural development offices in the area frequently droughts, hunger and the recent floods are among the most serious problems affecting more than thousand people almost every year changes in climate will only make the situation worse. Drought and flood are most serious climate related natural hazard affecting the from time to time. Rainfall variability and associated droughts have been major causes of the food shortage and famine because agriculture is the foundation of the national economy and constitutes the primary source of livelihood for the overwhelming majority of the population [4].Even though there are few research works which have been done by different researchers on the vulnerability of agriculture to climate change, they focused on farmers' vulnerability by considering the socio-economic aspects and neglecting the physical factors which play a great role on its vulnerability to any change [5]. In the Studies areas Lay-GayintDistrict have long period of time variability in climate change in climatic conditionlike itoccur prolonged droughts, increase level of temperature, death of crop duty shortage rain, storms and flooding. As a result of this factor affect livelihoods of the people especially rural household in the study area their high impact to climate change. For this reason, climate adaptation strategies become veryimportant; and investigations into the lack of understanding of those constraints facing poorcommunities that may impede their ability to adaption should be prioritized future climate change.

Research methodology

Description of the Study Area

The study was conducted in Lay-Gayint district. The district is found in South Gondar Zone of the Amhara National Regional State, Ethiopia. It is located between $11^{0}02'$-$11^{0}39'$ N of latitude and $38^{0}06'$-$38^{0}38'$ E of longitude. Its altitude ranges between 1300-3500 metres above sea level. It has an area of 132031ha [4]. With a population of 242 900, the district is among the most populous areas in the country. Its population density rate of 183 km^{-2} is nearly three times higher than the national average of 66 persons indicating the pressure on the resource base of the area. Households are of fairly large size in the district. According to the A.D. 2000 projection, the population is distributed along 40433 households in the district, averaging 5.2 persons per household.There are four agro-climatic zones in the district namely wurch, dega, weinadega, and kola. The alpine zones are areas of extreme altitude (over 3200 metres above sea level) with a low temperature and short growing seasons. The wurch area comprises 2% of the total area of the district. The dega and weinadega zones are the most important zones in which the majority of the households live. The dega lies between 2300–3200m altitude, while the weinadega zones comprises between 1500–2300 m above sea level. Over 84% of the areas in the district are found in both zones making them important for the settlement and survival of the households in the district. Lowland areas, which lie below 1500 m above sea level, are classified under the kola zone; the climate is hot, over 27^{0c}, and dry with rainfall less than 450mm. The shortage of farmland has led to the removal of forests to hillside terracing in the area. As population grew rapidly there was a need for more farmland, which was made by removal forests and by resorting to marginal lands that are not conducive to farming. Forest resources in the Lay-Gayint district have been decreased over time, owing to the population growth and the growing competition for resources. In spite of dwindling tree resources, the cultivation and management of woody species remains important activity in the farming systems of the district. Since the natural forests of the district are exhausted the only available resources in the production of forest products are the agroforestry practices that are implemented side-by-side with the agricultural and livestock production. Some of the common agroforestry practices of the district include scattered trees on farmland, live fences, homegardens, woodlots and farm boundaries. From these agroforestry practices the people produce farm implements, construction material, fuelwood, medicine, fruits and other products. The farmers have used trees for numerous purposes for centuries, during which they have accumulated extensive knowledge about the management of indigenous tree species for these purposes in the past. The district has four types of soil, comprising of Red 16%, Brown 48%, Black 30%, and White 6 %. Rainfall is mainly uni-modal in the district. With the exception of some showers in the belg, which accounts for only 5% of the crop production the majority of rain is received during the meher season

Variables hypothesized to affect adaptation decisions by farmers

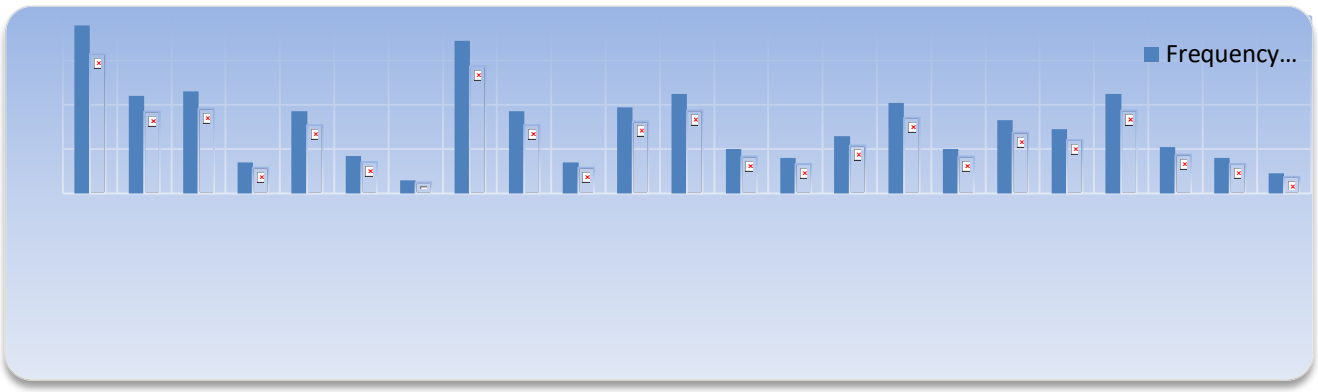
Variable	Description Household characteristics	Value
Gender	Gender of the head of the farm household	1= male 0=Fem
Household size	Number of familymembers of a household	Number
Farming Experience	Number of years of farming experience for the household head	Years
Education	Number of years of formal schooling attained by the head of the household	Years
Age	Age of the head of the farm household	Years
Farm size	Determine if the farm is large-scale or small-scale	1= large0=small
Extension contacts	If household as access to extension services	1=yes,0= no
Climate Information	If household gets information about weather, climate	1=yes,0= no
Land Tenure	If land use is owned land	1= rent
Annual Income	Annual income from farming income	Number
Distance from	Distance from house to the nearest market in km	Kilo meter

Independent variables

Results and discussion

Socioeconomic and Demographic Characteristics of Respondents

The socio-economic characteristics of farmers observed in this study were sex, age, marital status, family size**,** and farm size and education level. Although the majority of the respondents were male headed HHs, female household heads were also included in the household survey. The households interviewed, the number of male respondents was found to be 63%, while females were 37%.



General characteristics of the respondent (Household survey 2017)

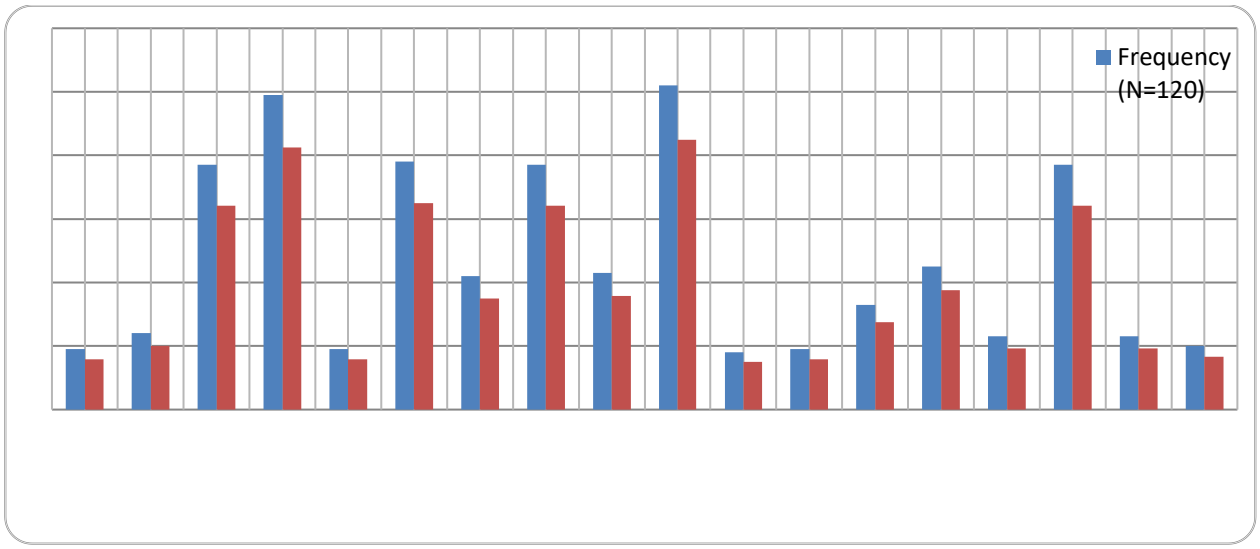


Figure 3: General characteristics of the respondent (Household survey 2016)

Households' Perceptions of Changes in Rainfall Temperature and sunshine hours over theLast20 Years

Households' Perception	Percentage of the respondents		
	Temperature	Rainfall Amount	Sunshine hours
Perceived an increase	88.3	2.5	92.5
Perceived a decrease	5.0	89.2	3.3
Perceived no change	4.2	5.8	1.7
Did not know	2.5	2.5	2.5

The impact of ClimateChange

The impact of climate change in the Lay-GayintDistrict different types of problem happened. Those are decrease livestock productivity directly (through higher

temperatures impact on), the rainfalldecreasing trend(Y=-17.21X-41) R^2=0.68,(Y=-7.499X-14574) R^2=0.64 that 5% level ofsignificance based on National Meteorologicaldata last 30 year, increased incidence of pest attacks, increase in temperature,reduction in soil fertility, the manifestation and plant soilborne diseases. Beside these negative impacts on human health affecting human resource availability. The impact of these changes on agriculture is exacerbate by the lack of adaptation strategies, which are increasingly limited due to the lack of institutional, economic and financial capacity to support such actions [7] Increasingly variable growing season conditions (shifts in start of rainy seasons, length and quality of rains, etc) are disrupting subsistence agricultural production leading to famine and severe loss of livelihoods. Improved seasonal forecasts and application of these results at the community level is a high priority in ensuring communities transition smoothly to the changing climatebe more intense, andworsening the already arid conditions [9].

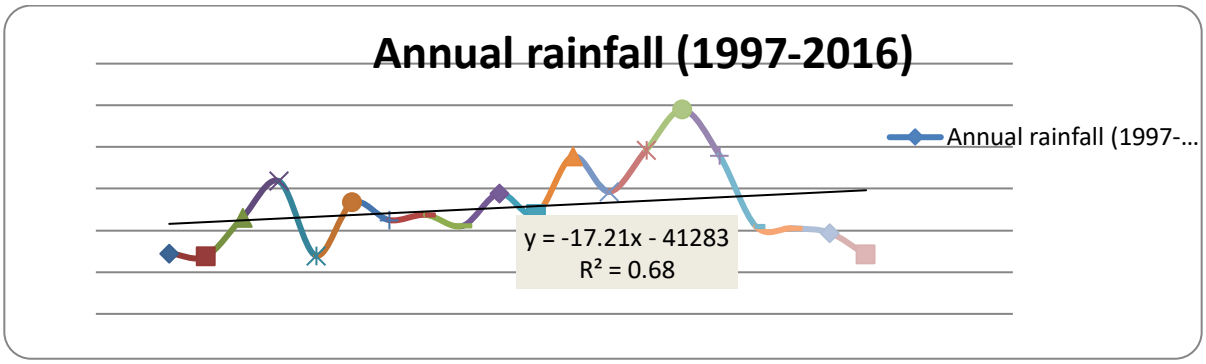


Figure: 4:Annual rainfall distributions (1998-2016).

Trend of climate change:

Though the frequency and extent of feeling the impact varies, the frequently experiencedclimatic shocks are prolonged drought and delay in the onset of rain, erratic and lowprecipitation, and heavy and unseasonal rainfalls. The relatively recent major drought andrain delay events that hit the zone and marked in the minds of respondents interviewed as the most notorious climate shock in their lifetime.

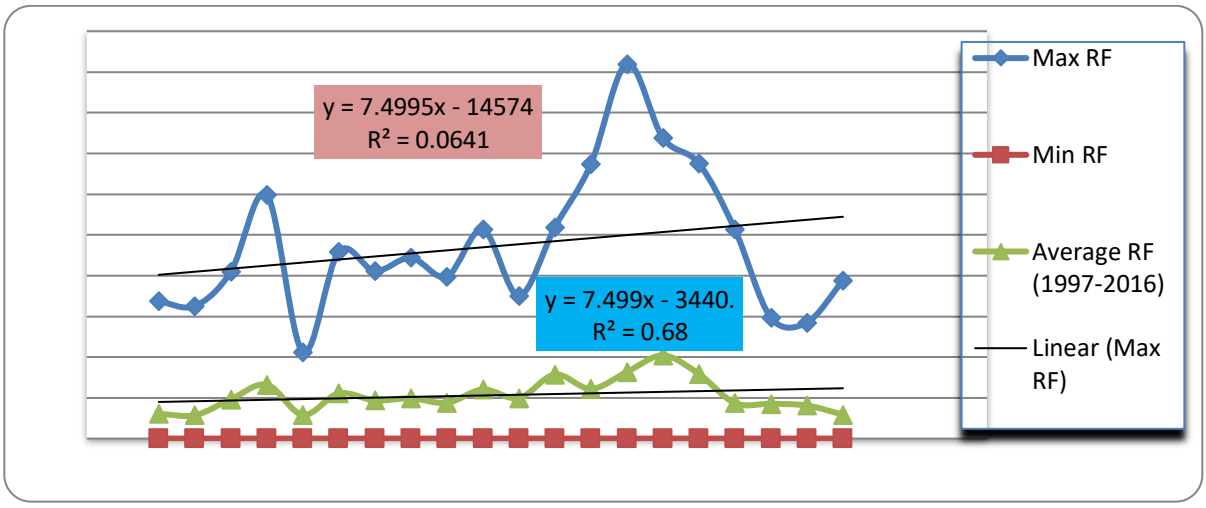


Figure: 5 Average annual, Minimum and maximum annual rainfall distribution (1998-2016)

Annual and average annual temperature of Lay-GayintDistrict

The distribution of temperature, the maximum and minimum mean monthly temperatures were 43.88 ^{o}C and 6.62 ^{0}C, respectively. According to the result, the annual temperature and average annual temperature starting from 1996-2016 increase rate 0.09^{o}c and 0.062^{o}c respectively (Figure 5). Despite this fact, the trend equation and R value imply the variations are significant in the case of annual temperature since their respective R value was **R= 0.01** (which is >0.5) which implies significant variability in the 1996-2016. states the average surface temperature has, since the mid 1970 increased by about 1°F or 0.5°C [2,3], states that the earth temperature has increased by approximately 0.74 ^{0}C.

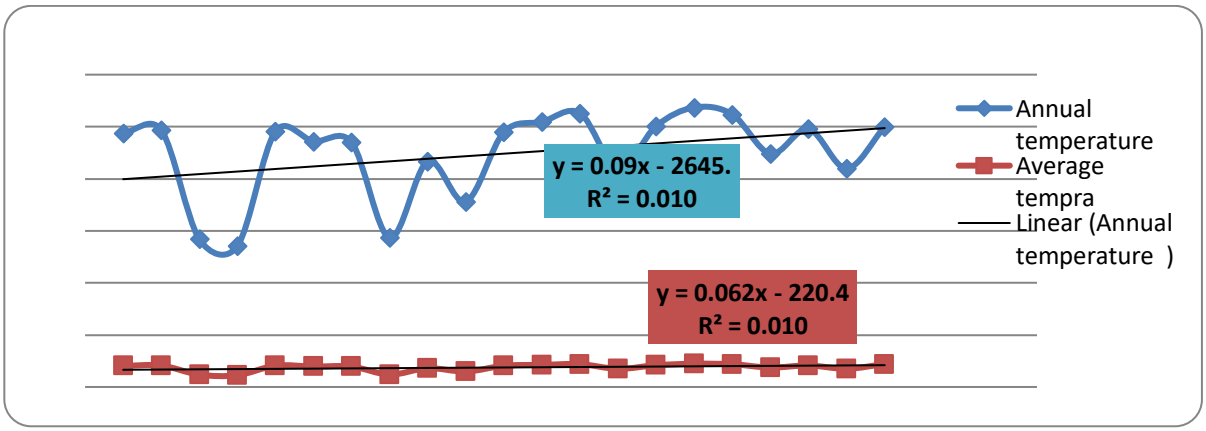


Figure6: Trend of annual temperatureinLay-GayintDistrict from 1997-

Climate change its impact

During long drought and delay in the onset of rain land becomes dry and difficult to plough, forage deficit leads to weakness and oxen mortality (engine of subsistent cultivation), and lack of precipitation hinders seed cultivation and germination of cultivated seeds.

The households also suggested the situation has also created a good opportunity for weeds to stay in the cropping land so that it latter emerges with crops and out-compete them. Erratic precipitation period has also increased an opportunity for crop pests.long droughtand delay in the onset of rain led to poor grass regeneration/forage deficit, waterShortage and heat stress on livestock, and consequently increased the mortality of thelivestock, vulnerability to diseases and physical deterioration due to long distance travel forwater and pastures [10]. The householdinterview data suggests that 31% livestock per household were died during the 2007/08drought.

ClimateChangeAdaptationStrategies

Adaptation is one of the policy options for reducing the negative impact of climate change [13]. Adaptation to climate changerefers to adjustment in natural or human systems in expected climatic stimuli or theireffects, which moderates harm or exploits beneficial opportunities [3].

Table 5: Summaryof adaptation strategies used byfarmers

Adaptation strategies	No of respondents	Percent
Soil conservation practice	12	10
Adjusting planting date	27	22.50
Crop diversification	20	16.67
Use of improved crop varieties	16	13.33
Use of irrigation	45	37.50

Determinants of Farmers the impact of climate change adoptees Strategies

The model is fitted using STATA version 12. However, prior to running the final regression analysis, the existence of multicollinearity using was checked Variance Inflating Factor (VIF) and the contingency coefficient (CC) methods. The Multi-nominal model (MNL) model was run taking climate adaptation method as an independent variables and dependent groups to be compared with. In order to see the probability of a particular choice of adaptation for a unit change in the independent variables, the regression coefficients, average marginal effect, and their significance levels were used. The likelihood

ratio statistics from the MNL model indicated that statistics was highly significant at $p < 0.001$,

Multi-nominal model (MNL) selection of farmer to take away climate change

	Used improved verity				**Adjustment planting**				**Crop diversification**				**Soil water conservation**			
Ind	**Coef.**	**Std. Err.**	**Z**	**P>z**	**Coef.**	**Std. Err.**	**Z**	**P>z**	**Coef**	**Std. Err.**	**Z**	**P>z**	**Coef**	**Std. Err.**	**z**	**P>z**
Gender	1.19	1.74	0.69	0.491	2.67	1.70	1.57	0.016	.588	1.763	0.33	0.738	1.51	2.66	0.57	0.569
Age	-1.027	-.79	-1.02	0.008	-.52	.56	-0.93	0.35	-.785	.622	-1.26	0.207	-1.05	.975	-1.08	0.281
Farm size	-.199	-1.91	-0.10	0.018	3.00	2.14	1.40	0.0061	-2.97	2.24	-1.33	0.008	3.95	2.14	1.85	0.065
Education	1.48	1.32	1.11	0.063	-1.04	1.20	-0.86	0.087*	1.38	1.53	.09	0.040	1.85	.898	-2.07	0.039
Farm exper	1.14	1.57	0.73	0.467	-1.44	1.58	-0.91	0.364	2.51	1.545	1.63	0.103	.487	.295	1.65	0.099
Market f dis	1.18	1.317	0.90	0.367	-1.05	.975	-1.08	0.281	-1.49	1.172	-1.28	0.202	-1.05	.975	-1.08	0.281
Extinction cont	-.29	0.205	-1.44	0.001	-3.41	1.57	-2.16	0.03	-3.79	1.57	-2.40	0.016	.487	.295	1.65	0.099
Credit serve	-4.90	3.00	-1.63	0.003	4.449	2.42	-1.83	0.067	6.61	2.59	-2.55	0.011	-7.46	2.74	-2.72	0.007
Land tenure	1.51	2.66	0.57	0.569	-.813	2.14	-0.38	0.704	-1.23	2.03	-0.61	0.543	-1.05	.975	-1.08	0.281
Annual inco	-2.47	1.42	-1.74	0.083	-4.09	1.37	-2.98	0.003	-.869	1.32	-0.66	0.511	-2.31	1.28	-1.80	0.071
Nonfarm in	2.08	1.49	1.40	0.162	.471	1.37	0.34	0.732	-.502	1.481	-0.34	0.734	1.51	0.66	0.57	0.069
Farm to farm ex	-2.14	1.80	-1.19	0.233	-1.87	1.73	-1.08	0.28	-3.87	1.89	-2.05	0.041	-4.96	2.12	-2.34	0.019
Constant	12.30	6.28		0.05	18.67	5.8	3.19	0.001	24.3	7.106	3.43	0.001	16.6	6.9	2.41	0.016

			1.96	0		6										
Using irrigation (base outcome)				**No of observation=180**					**Log likelihood = -65.41511**				**Pseudo R2 =0.6446**			
LR chi2(48) = 237.27				**Prob > chi2=0.0000**												

Source: Own survey results, 2016

The findings further reveal that access to extension services for climate change information increases the likelihood of smallholder farmers adapting to new crop variety and diversify their enterprises (P<0.09). This is because access to extension service assists farmers through educational trainings; help them improve their farming methods and techniques through the provision of up-to-date information [8].

The study findings are similar to [11] found in Ethiopia, that having access to extension services increases the probability of using improved crop variety and soil and water conservation techniques. The adaptation capacity of the smallholder farmers on human capital was affected by the low level of education within the farmers, since a majority of the smallholder farmers had no formal education (54.7%).

Emergency aid and Productive Safety Bet Program (PSBP): During emergencies NGOs and government were providing emergency food, seed varieties,and health services for the affected people. On the other hand, the safety net 22 program is an extension of ‘’**the food for work’’** program of Derg-regime(previous Ethiopian regime), but now modified to have two components, **public work anddirect support.** In case of public work, money is given after the individuals have participated in community development work such as water harvesting, road construction, spit irrigation,soil water conservation and other development activities. There are five working days per month for six consecutive months a year, and 180birr/person/year is given. Direct support isgiven for children, disabled people, and old people without any need to work. In principle the program’s beneficiary should be ‘’the poor of the poor ‘there are still complaints on inclusion of non-poor larger family size households that get disproportionate amount of aid/money compared to the targeted poor households. Theprogram is also challenges by lack of communities’ eagerness to participate in developmentwork, insufficiency the aid (only ~0.5$/person/each working day), aid delay, and fruitlessnessof the activities or their negative consequences (harvested water caused malaria emergence,quality deterioration and water seepage)

Constraints toAdaptation Strategies

No	**Constrains to Adoption Adaptation Strategies**	**Frequency**	**Percentage of Farmers**

1	Lack of information about long-term Climate change	35	29.17
2	Lack of Appropriate adaptations strategies/options	14	11.67
3	Lack of access to timely weather forecast information	15	12.50
4	Limited access to agricultural extension services	2	1.67
5	Lack of irrigation schemes	45	37.50
6	Lack of credit or insurance services and abject poverty	3	2.50
7	Shortage and high cost of farm inputs	6	5.00

Level of education is one the statistically significant explanatory variable at 5% level of significance as shownby a p-value of 0.045 as shown in the table 4.5. This result is in support of the findings of [12] who found a positive relationship between education and adaptation to climate change in Ethiopia.

Farm size is also statistically significant explanatory variable in our model. The positive sign of its coefficientindicates the presence of positive relationship between farm size and farmers decision for taking climate changeadaptation measure

Non-farm income is high significant explanatory variable in this model with p-value of 0.000. Its coefficient hasnegative which satisfy the hypothesized direction of effects of the non farm income in adapting to climatechange.

The number of the livestock owned by the farmer is highly significant (at 1% significance level) in this study. Its direction of effect is also positive which show the positive effect of the livestock size in influencing the farmers' decision of taking adaptation measure. A unit increase in the number of livestock adaptation is one of the policy options for reducing the negative impact of climate change [13]. Adaptation to climate change refers to adjustment in natural or human systems in expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities [2,3]

Access to credit is also highly significant variable with p-value of 0.003. The coefficient of this variable ispositive which show the positive influence of this variable in adapting to climate change/ Ascompared to the farmer who has no access to credit, the likelihood for

adapting to climate change increases by5.53% for the farmer who has credit access holding other things at their respective mean [14].

Farmers-to-farmers extension service

is also the significant explanatory variable. This variable positivelyaffects the adaptation decision hence it has a positive coefficient. As compared to the farmers who have no accessto farmers to farmer's extension service, the probability of adapting to climate change increases by 3.8% forthose who have access to this service keeping other things at their respective mean [15,16].

Conclusions

The study findings revealed that climate change has a negative effect on smallholder farmers' livelihoods. Farmers have experienced extreme weather events such as droughts and reduced rainfall, yielding a negative effect in their crop production since there were lots of crop failures events due to prolonged droughts. The smallholder farmers worked around this situation by employing some coping strategies such as, eating less food a day, changing diet, borrowing money and some received food parcels from their relatives. These coping strategies, however, negatively affected the food security status of the farmers and compromised their well-being.

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