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# Smallholder farmer's adaptation strategies to climate change: The case of Soro Woreda, Hadiya Zone, South, Ethiopia

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**Key words: :** Adaptation, Climate change, Multinomial logit model, Smallholder farmers, Soro Woreda

**Abstract**

The aims this study is examine smallholder farmer's strategy to climate change factors that influence farmers' choice of adaptation measures and identify adaptation methods to climate change in Ethiopia using Soro district as a case study. Both qualitative and quantitative data obtained using primary and secondary sources. The primary data were collected from 240 randomly selected sample respondents using a survey questionnaire. The adaptation strategies considered in the MNL model analysis were drought tolerate varieties, adjusting planting dates, improved crop varieties, soil and water conservation practices and irrigation. The result from the multinomial logit analysis showed that gender, farm income, agricultural extension services, landholding size , livestock holding , distance to the market, farming experience, agro-ecology, farmers to farmers extension and soil fertility status were significance factors influencing to farmers' adaptation strategies. On the other hand, in this finding, age, household size, credit and access to climate information were not being a significant influence in choice of strategies. The basic barriers to climate change adaptation on the farmers' side are luck of knowledge, lack of capital, lack of sufficient land and luck of information. Therefore, future policy should focus on awareness creation on climate change to adaptation through different ways such as mass media and extensions, encouraging informal social networks, improving the availability of credit and enhancing research on use of new crop varieties are more suited in different agro ecological zones.

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## Introduction

Ethiopia has become a crucial challenge for sustainable development on the continent. This challenge is composed of the likely impacts on ecosystem services, agricultural production, and livelihoods (Abid, 2019). A range of climate models suggests average temperature increases between 3ºC and 4°C in Africa by the end of the 21st Century. This wills 1.5 times the global mean which will be its impact far greater than expected (Bryan, 2015). Climate change affects agriculture and agriculture also affects climate change. Many African countries have economies largely based on weather-sensitive agricultural production and are particularly vulnerable to climate change (FAO, 2016). According to (Borona, 2015) agreed that as rain-fed agriculture is a sector that is highly vulnerable to climate variability and change.

Ethiopia is one of the countries in East Africa exhibiting variable climatic conditions. It has diverse AEZs which are characterized by a dazzling variety of microclimates and corresponding weather patterns (Astawsegn, 2014). Ethiopia has a tropical monsoon climate characterized by wide topographic induced variations. Mean annual rainfall distribution ranges in the country from more than 2000mm over the southwestern highlands to a minimum of below 300mm over the southeastern and northwestern lowlands (Abebe and Arega, 2019). Rainfall distributions over the country are also strongly incompatible among different seasons (Kew, 2017). Moreover, mean annual temperature varies widely from less than 15°C cover the highlands and above 25°C in the lowlands (Kibamo, 2011). According to the (Sisay *et al.*, 2019) study result indicates that vulnerability of small holder farmers by climate change vary from district to districts based on adaptive capacity of farmers and natural resource endowment (water). However, the researcher did not identify climate change variables and indigenous knowledge as adaption strategy for climate change. Adapting to current climate variability is the best initial step in preparing for future climate change. The communities in the study area have been dealing with practices of land and water management, and food losses to constitute a fundamental parts of adaptation practices (FAO, 2017).

Ethiopia is one the agrarian country whose main livelihood depends on agriculture as source of income. Farmers whose livelihoods depend largely on rain-fed agriculture were faces with different climate variability (Aemro, 2012). Condition such as being low economic development, inadequate infrastructure and lack of institutional capacity contributes Ethiopia for vulnerability to climate change.

Ethiopia is highly vulnerable to climate change, variability and extreme climate events due to its low level of socio-economic development, inadequate infrastructure, lack of institutional capacity and a higher dependency on natural resources. Climate related hazards in Ethiopia include drought, floods, frost, strong winds, high temperatures, lightning, and others (Tadesse, 2015). According to (Mussa, 2015) annual decrease in crop production over the past 10 years, due to pests and diseases, uneven distributed low rainfall and extended drought periods. Agriculture dominates Ethiopia's economy (Alemu, 2019). Climate change and variability could impose a heavy burden on the poor smallholder farmers' (Nega, 2015).The variability of rain fall and the increasing temperature were a cause for frequent drought and famine. At the national level, (16) suggests that climate change may reduce Ethiopia's GDP compared to a baseline scenario by 2-6% by 2015, and by up to 10% by 2045. Thus, mitigation and adaptation measures are meaningful to cope up the effects of climate change.

However; the agricultural systems in Ethiopia are almost exclusively rain-fed. Of an irrigation potential of approximately 2.7 million hectares of land, only 2%–3% of the cropland is currently irrigated (Aragie, 2013). Agriculture dominates Ethiopia's economy (Alemu and Mengistu, 2019). Climate change and variability could impose a heavy burden on the poor smallholder farmers' (Teferi *et al.*, 2018). The variability of rain fall and the increasing temperature were a cause for frequent drought and famine. At the national level, (WB, 2018) suggests that climate change may reduce Ethiopia's GDP compared to a baseline scenario by 2-6% by 2015, and by up to 10% by 2045. Thus, mitigation and adaptation measures are meaningful to cope up the effects of climate change.

Agriculture has a multiple roles in the economy of Ethiopia. Food security, 73% of employment, 36.7% of the GDP of the country and 70% of raw material requirements of local industries are drawn from this sector (NBE, 2016) .Since Ethiopia's agriculture is tremendously rainfall dependent; it greatly suffers from the risks associated with a decrease and a high variability in rainfall. It is a major threat to the sustainability of growth of the country due to its negative impact on agricultural output. Long-term records indicate that there have been severe and a repeated rise in temperature and rainfall failures resulting in severe food insecurity, including famines in Ethiopia due to significant loss of crops and livestock.

Agriculture is the mainstay of the Ethiopian population and a key sector of the country's economy. Agriculture completely dominates Ethiopia's economy and any climate-change impacts on agriculture will be considered in the coming decades (Taye *et al.*, 2018). However, on account of climatic, social and institutional factors contributing to low production and productivity, the major factors responsible for low productivity include reliance on traditional farming techniques, soil degradation caused by overgrazing and deforestation, poor complimentary services such as extension, credit, marketing, infrastructure and climatic factors such as drought and flood this made the agriculture is unable to feed the population. These problems are further intensified by climate change (Belay *et al.*, 2017). The sector is dominated by small-scale mixed crop-livestock production with very low productivity (Alemu, 2019). Ethiopia suffers from increasing frequency and intensity of climate-related disasters: recurrent droughts, floods and erratic rainfall (CSA, 2009) which need to be adapted by appropriate adaptation strategies.

The communities in the study area have been dealing with practices of land and water management, and food losses to constitute a fundamental parts of adaptation practices (Creswell, 2013).

According to (Hailu, 2016) research conducted on impact of climate variability on food security in rural household level in Shashogo district in Hadiya zone. Agriculture is the main economic activity and livelihood strategy for smallholders in Shashogo district which involves more than 85 percent of the population.

Farmers' Perception on Soil Erosion and their use of Structural Soil Conservation Measures in Soro district, Southern, Addis Ababa University, Ethiopia. The soil loss by erosion is severe in highlands and continuous to threaten man's wellbeing as bulks of country's people are reliant on agricultural production land (Patrick, 2014). According to (SWEED,2020) Study conducted on investigates effects of climate change and variability on rural livelihoods and the responses to generate analytical information regarding socio economic condition of the community, perception of farmers towards climate change and variability in their locality, adverse effects of climate change on farmers' livelihoods, coping mechanisms and adaptation strategies of farmers to the changing climate and existing variability and challenges that hinder farmer's and adaptation strategies of farmers to the changing climate and existing variability and challenges that hinder farmer's adaptation.

Therefore, deliberate and conscious adaptation that can manage with these evolving impacts is an immediate concern in agriculture. Particularly in countries like Ethiopia, where agriculture is highly tied with climate, adaptation is a priority measure.

According to (Hameso, 2017), Ethiopia is vulnerable to the impacts of climate change mainly due to poor adaptive capacity of communities & high diversity of agro ecologies, cultures, production systems and livelihood strategies. As (Kothari, 2004), Ethiopia's climate is naturally both highly diverse and extremely variable, and as a consequence of this nature climate of the country dramatically changing in recent years.

According to Soro Woreda Agriculture Development Office (SEEDO, 2020) information obtained Soro is one of the most vulnerable Woreda to climate change in Hadiya Zone. Climate change posed a huge threat to farmers in the district due to their overwhelming reliance on small-scale agriculture, it is the most severely affected district by drought and agricultural production in the district is frequently affected by climate change related shocks.

This study is focuses on level smallholder farmers' perception to climate change, identifying choice of adaptation strategies and identifying determinates using Multinomial logit (MNL) model in the area. This facilitates to intend suitable policies and strategies in that local context. Such information was in truth negligible in Soro district in particular.

In this regard, no empirical study has been conducted to examine the perception of farmers to climate change, identify adaptation choices and their determinants in the study area to date to the best of the researcher knowledge. As results, the primary motivation to get on this research was to investigate and fill the existing knowledge gap on farmers' perception and adaptation strategies to changing climate and their determinants in the area. The objective of this study is to examine smallholder farmers' adaptation strategies to climate change in case of Hadiya zone, Soro Woreda.

## Material and methods

This study was conducted in three Kebeles purposively selected of 36 and Soro Woreda is one the thirteen rural Woreda in Hadiya Zone, SNNPR state which is located. It is located at located at 7° 30′-7° 43′ North latitude and at 37° 35′-38°05′ east longitude (Fig. 1). It is situated in the Southern extreme of Hadiya Zone and bordered by Gombora Woreda (District) in the North; Oromiya region (Omo River) and Yem special Woreda (District) in West; Lemo Woreda (district) and also Kembata Timbaro Zone in Northern East and East.

The total land area of the districts is 56,012ha which comprises of 33 rural Kebeles and 3 growing municipalities in the Woreda SWFED report (2020).The administrative center Soro Woreda (District) is Gimbichu town which 264 km far from Addis Ababa, 200km far from Hawassa city and 32 km far from Hossa'ina town. The total population reported The CSA (2007) Soro district to was 196,693.The current population census indicates that population is 239357 before division which out of 120787 males and 118570 females .About75% are settled at highlands ' Dega', moderate climate 'Woina-Dega' and the rest 25% are settled at low area 'Kola'. But from this total population around 16757 household head are found in 36 Kebeles.

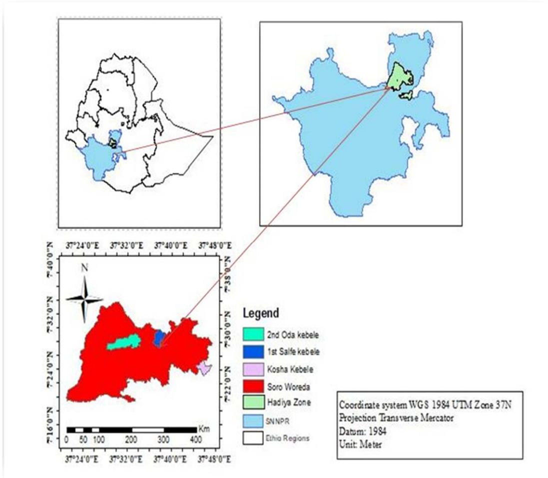


**Fig. 1.** Location map of the study area

Agriculture is the major livelihood of the people in the study area. Crop production is rain fed during the rainy season, additionally for some households by irrigation in the dry season. Maize, haricot bean, teff, pea, sorghum, enset (false banana), sweet potato and potato as well as different vegetables and fruits such as tomato, mango, and avocado are widely grown in the Woreda. Alternatively wheat, beans, papaya, pepper and onion are grown in small amounts. Chat and coffee are the main cash crops in the study area.

### *Data collection and Sources*

The study used both primary and secondary data sources to collect qualitative and quantitative data. The primary data was collected from the smallholder farmers' on demographic, socio-economic and institutional factors were collected from 240 sample households of Soro district using semi-structured questionnaire purposively selected in each respondents. Secondary data were collected from documents of different offices in Soro district and a 24 years rainfall and temperature data for the period 1997-2020 have been collected from the National Meteorological Agency (NMA) branch office in Hawassa City.

This study was conducted on smallholder farmers' adaptation strategies to climate change in (Soro Woreda by using cross-sectional data in the production period 2020. The study focused on the determinant factors that influence farmers' choice of adaptation to climate change.

*Sampling techniques*

The study followed a multi-stage stratified random sampling procedure where a combination of purposive and random sampling procedures were used to select sample Kebeles4 and households, respectively. To select the sample for this study, three-stage sampling method was employed. At the first stage, Soro (*District)* was purposively selected due to the fact that the *District* is frequently vulnerable to climate related problems. In the second stage, three kebeles were selected from the 3 agro-ecologies, using probability proportional to size. In the third stage, in the three selected sample kebeles, households were stratified into two strata, namely Adaptation choices and no adaptation, from which sample households were randomly selected and in order to know perceptions to climate variability and change between gender groups households in the selected kebeles were categorized in to female and male headed households. Then, sample households were selected using simple random sampling (SRS) with probability proportional to size technique.

According Soro Woreda Finance and Economic Development Office (SWFED, 2020) unpublished source the total household heads are 16757 in the 36 Kebeles and 240 sample household heads were selected randomly using a sample size determination formula. To compute estimation of population proportion in case of finite population the following formula was suggested by (Green, 2003).

Representative samples from the households of selected kebeles were based on scientific formula at required degree of confidence. Therefore, representative sample of these households have been calculated based on formula for sample size determination and for finite population. The formula is given as:

$$n = \frac{(Z)^2 * p * q}{(e)^2 (N-1) + (Z)^2 p * q} \quad \ldots\ldots (3)$$

Where:

n= sample size desired

Z= is the abscissa of the normal curve that scratch off an area α at the tails (1- α equals the desired confidence level. The value for Z is found in statistical tables which contain the area under the normal curve. e.g., Z=1.96 at 95%confidence level.

P= the population proportion (assumed to be 0.8 since this would provide the maximum sample size)

q= 1-p is estimate of the proportion of the population to be sampled (0.2)

e = is the desired level of precision or error limit (5% error or 0.05)

N= the population size (16757)

1= theoretical constant

Substituting this numbers and computing the process by using the above formula it gives:

$$n = \frac{(1.96)^2 * 0.8 * 0.2}{(0.05)^2 (16757-1) + (1.96)^2 0.8 * 0.2} \quad \ldots\ldots (4)$$

$$= 240$$

Based on the above formula, the sample size for the study is 240 household heads. Sample size for each kebele was determined through sampling with probability proportional to size technique.

*Econometrics analysis*

Econometric model is used to study relationship between variables empirically. Thus, the multinomial logit model (logistic regression function) is used to analyze factors influencing a Smallholder farmers' decision to start every adaptation on the entire to climate change as explanatory variables.

*Model speciation and model estimations*

There are many specific probabilistic choice models, and two of the most widely used models are the multinomial logit (MNL) and multinomial probit (MNP) models. Technically, these models are very similar. They differ only in distribution of the error terms. Multinomial logit (MNL) has errors which Independent of Irrelevant Alternative (IIA) and identically distributed according to the type-1 extreme value distribution 32 Multinomial probit (MNP) has errors which are not necessary independent, and distributed by multivariate normal distribution (Green, 2000). This difference between MNL and MNP may seem rather minor, but in practice it has a big effect. The independent of MNL force an assumption called the independent of irrelevant alternatives (IIA) assumption. Essentially, IIA requires that individual evaluation of alternatives relatives to another alternative should not change if a third (irrelevant) alternative is added or dropped to the analysis.

Independence of irrelevant alternatives (IIA): The MNLM assumes that the odds for any pair of outcomes are determined without reference to the other outcomes that might be available. This is the independence of irrelevant alternatives property or simply IIA.

Multinomial Logit model (MNL) development consists of formulating model specifications and estimating numerical values of the parameters for the various attributes specified in each utility function by fitting the models to the observed choice data. The critical elements of this process become the selection of a preferred specification based on statistical measures and judgment. Under some circumstances, the model developer may impose constraints on the estimation to ensure desired relationships with respect to the relative value of different variables. And also to estimate adaptation strategies and identify the adaptation strategies from No adaptations strategies, we utilized empirical models. In order to achieve the objectives, the study was made use of cross-sectional smallholder farmers' from household survey data was collected from the social societies of Soro Woreda from selected sample households. The data collected was also analyzed and discuss appropriating adaptation strategies, descriptive statistics and multinomial logit regression model analyses.

To explain the multinomial logit model, let y denoted vector of adaptation alternatives for climate change to selected household. Let the adaptation alternatives smallholder farmers' choice are dependents on demographic factors, socioeconomic factors and institutional factors of the smallholder farmers'.

In matrix notation, let X be the matrix of independent variables,β be the coefficients and K be the category, then we would have the econometric model is specified as:

Yi = f (β'Xi) = (age, sex, education, household size, on farm income , landholding size, livestock, agricultural extension services, farmer to farmer extension ,climate information, credit, distance market, farming experience, agro-ecology and soil fertility status).The empirical multinomial logit model for the choice of adaptation strategies is given as follow;

$$ln\left[\frac{Pij}{Pik}\right]=\beta o+\beta 1age+\beta 2sex+\beta 3edu+\beta 4hhsize+\beta 5frinc+\beta 6lhsize+\beta 7TLU+\beta 8ariexs+\beta 9climinfor+\beta 10credit+\beta 11dmkt+\beta 12ffxts+\beta 13exper+\beta 14Ae+\beta 15hpro+\mu_i \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.(\mathbf{1})$$

Where:

Yi=Dependent variables with more than two categories variables (Adaptation strategies choices methods)

Xi =sets of factors or predictors

P[ ] = is a probability function,

i = cases, j categories, k = independent variables

βo=Coefficient of intercept

β1-β15=Coefficient of independents (explanatory) variables or Parameters to be estimated

$\mu_i$ = Error (Disturbance) term or Error term controls other variables that are not controlled by other variables

The multinomial logit model for adaptation choice can be specified as in the following relationship between the probability of choosing alternatives and a set of explanatory variables Greene (2003).

$$P(yi = j) = \frac{e^{\beta' jXi}}{\sum_{k=0}^{6} e^{X\beta' K}} \quad ,J = 0,1,2 \text{ .............. } (7)$$

Equation (9) is normalized to remove indeterminacy in the model by let β0=0 and the probabilities can be estimated as:-

$$P(yi = j) = \frac{e^{\beta' jXi}}{\sum_{k=0}^{5} e^{X\beta' K}} \quad ,J = 0,1,2 \text{ .......J}$$

$\beta_0$=0.................................................. (8)

Odd ratios in MNL are calculated in the exact same way as in binary logit treating as follows:

Choice 0 as the base, the odd ratio for any other choice j is;

$\frac{P(yi=j)}{P(Yi=0)} = e^{\beta jxi} (e^{\beta 2x}, e^{\beta 3x}, e^{\beta 4x}, e^{\beta 5x}, e^{\beta 6x})$......................................................(9)

Where,

e=2.718281828≈2.71828

i = cases, j categories, k = independent variables

j = 5; Adjusting planting dates, Use of crop tolerant varieties , Soil and water conservation practices, Use of Irrigation and use improved crop varieties.

Probability of person 'i' choosing category 'j' must add to 1.0:

And the choice probability for any other choice k is;

Where k=is choice probability number (1-5)

$\frac{P(=k/X)}{P(Y=0/X)} = e^{\beta kXi}(e^{X\beta 2}, e^{X\beta 3}, e^{X\beta 4}, e^{X\beta 5}, e^{X\beta 6})$..................(10)

## Results and discussion

*Econometric e results of the multinomial logit model*

The results of MNL model showed how factors that influence farmers' choice of adaptation measures in the study area. The MNL adaptation model with these reorganization choices was regress and showed some significant levels of the marginal effects estimates. Table 1 represented the results of MNL regression model. The likelihood ratio statistics as indicated by chi-square statistics (Likelihood Ratio chi-square (60) = 217.57 are highly significant (P < 0.001, =0000), signifying the model has a strong explanatory power. In all cases, the estimated marginal effects should be compared with the base category of drought tolerate varieties. Coefficient estimations from the multinomial logit model can tell about the direction effect not the magnitude effect. Therefore, we see how we can compute MNL results with the level of statistical significance the magnitude of effect by using STATA command marginal effect after multinomial logit regression and it gives marginal effect or elasticity.

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*Gender of households head*

Sex of the household head increase the probability of up taking irrigation as adaptation measures to climate change, keeping other variables constant. Also as can be observed in Table 1, sex of household level significantly increase irrigation in the study area. One sex difference increase in the number of number of household head promotes 10.7% irrigation at 1% significant level. This suggests that being take awareness on sex difference would improve access to information, capable to interpret the information, easily understand and analyze the situation better than less than awareness take on sex of farmers. The study was hypothesized that farmers with higher levels of education are more likely to better adapt the climate change. The result of this study indicated that sex status increase the awareness of farmer about the consequence of climate change on agricultural productivity and has made farmers to adopt practical adaptation know-how to reduce the impact of climate change. This finding was similar with Temesgen *et al.* (2014), Abrham *et al.* (2017) and Bewuketu (2017).

They noted that higher levels of sex improve on farm area is likely to enhance information access to the farmer for improved technology up take and higher farm productivity.

**Table 1.** Marginal effects from the multinomial logit climate change adaptation model

| Explanatory variable | Drought tolerate varieties Coefficient p-value | Adjusting plant dates Coefficient p-value | Use improved crop Varieties Coefficient p-value | Soil and water conservation Coefficient p-value | Irrigation Coefficient. p-value |
|---|---|---|---|---|---|
| Age | -.0172995<br>0.160 | .0164238<br>0.490 | .0108565<br>0.643 | -.0064045<br>0.778 | -.0035763<br>0.768 |
| Sex | -.0524268<br>0.314 | -.108201<br>0.229 | .0278594<br>0.739 | .0261868<br>0.747 | .1065816*<br>0.004 |
| Edu | -.0354887<br>0.159 | .042283<br>0.329 | .0126481<br>0.780 | -.012233<br>0.786 | -.0072095<br>0.739 |
| Hhsize | -.0004162<br>0.984 | -.0476448<br>0.302 | .0241749<br>0.602 | .0145696<br>0.743 | .0093164<br>0.693 |
| Frincm | -.0191783<br>0.184 | -.0450459<br>0.128 | .0880723*<br>0.002 | -.0349454<br>0.218 | .0110973<br>0.008* |
| Credit | .1402069***<br>0.057 | -.0178123<br>0.826 | -.090695<br>0.262 | .0174837<br>0.836 | -.0491833<br>0.197 |
| Ariexs | .0765958<br>0.149 | .105714<br>0.207 | -.2103097*<br>0.002 | -.0785282<br>-.22408 | .1065281***<br>0.075 |
| Lhsize | .0454129*<br>0.005 | -.0107162<br>0.713 | -.055223***<br>0.064 | .0524087**<br>0.050 | -.0318824***<br>0.060 |
| Tul | -.0079429<br>0.555 | -.0046179<br>0.865 | -.0330949<br>0.223 | .0109719<br>0.673 | .0346839**<br>0.018 |
| Dmkt | .0270024***<br>0.074 | .0843866*<br>0.005 | -.0896874*<br>0.003 | -.019135<br>0.508 | -.0025666<br>0.870 |
| Climinfor | -.0257895<br>0.470 | -.0049682<br>0.947 | -.0852475<br>0.239 | .0932659<br>0.210 | .0227393<br>0.586 |
| Exper | .0067722<br>0.692 | .0268395<br>0.434 | -.0902846*<br>0.008 | .0271364<br>0.416 | .029536<br>0.114 |
| Ae | .6399055*<br>0.000 | -.1379507**<br>0.023 | -.2858775 *<br>0.000 | -.1523273 *<br>0.008 | -.0637501**<br>0.032 |
| Ffexts | -.0305153<br>0.433 | .1724035**<br>0.037 | -.1120779<br>0.132 | -.0451576<br>0.535 | .0153473<br>0.721 |
| Hpro | .0826491***<br>0.084 | -.0102495<br>0.892 | -.2126448*<br>0.002 | -.0159624<br>0.827 | .1562075<br>.3625 |

*Farm income*

Farm income of the household also a significant explanatory variables a shown in the above (Table 1). The finding of this analysis reveals that farm income of a household had a positive and significant influence on improved crop varieties adaptation methods in response to climate change.

A one percent (ETB) increases in the income of the household from the farm, the probability of farmers' to use adaptation strategies of improved crop varieties by 8.8%, holding other This suggests that being generate income would improve access to information, capable to interpret the information, easily understand and analyze the situation better than less farm income of farmers. The study was hypothesized that farmers with higher levels of education are more likely to better adapt the climate change. The result of this study is consistent with Seid Sani *et al.* (2016) and Tarfa *et al.* (2019) that farm income has a positive and significant impact on use of improved crop varieties as an adaptation strategy. They noted that higher level farm income is likely to enhance information access to the farmer for improved technology up take and higher farm productivity.

*Agricultural extension service*

It has negative and significant effect on improved crop varieties techniques at no access 1% significant level. However, it has positive and significant impact on irrigation farmers who has access to extension service at 10% significant level. This implies that farmers could not have access to extension service, which is a means of improving their skills, the probability of using improved crop varieties is decrease by 21% at 1% significant level, on the other hand, the probability of farmers are implement any irrigation adaptation method to climate change increase by 10.6% at 10% level of significant. Hence, agricultural extension service is main source of information concerning agricultural activities and natural resource conservation for the farming households.

*Landholding size*

Amount of farmers' land size is also significantly and negatively affecting these farmers who are use improved crop varieties an adaptation method to climatic change and irrigation adaptation method at 1% significant and 10 %significant levels respectively. One hectare increases in the farm size, the probability of the farmers use improved crop varieties and irrigation adaptation option to climate change decreased by 5.5 % at 1% level of significance and 3.2% at 10% level of significance, keeping other variables constant. The result is similarly to Aschalaw (2014) that revealed large landholding size decreases the use of irrigation in response to climate change. On another hand, landholding size is also significantly and positively influences soil and water conservation practices at 5% significant level. One hectare increases in farm size, the probability of the farmers' use soil and water conservation practices increases by 5.2% at 5% level of significance hold other variables constant.

*Livestock holding*

Livestock numbers of household is also a further statistically significant explanatory variable in this model. It has positive and significant impact on the probability of irrigation as adaptation strategies. A unit increase in the number of livestock owned by the household from its mean value increases the probability of improving use irrigation by 3.5% at 5 % level of significant, holding other things at their respective denoted. In this case, livestock is considered as an asset for the farmers and plays a very important role by serving as a source of income in order to work irrigation. Thus, encompassing a large number of livestock can support farmers' adaptive capacity to climate change. Conversely, livestock rearing is one part of agricultural activities which is also subject to climate change impact. As a result, as the number of the livestock increased the farmers will look for adaptation measures that safeguard their assets against climate related problems.

*Market distance*

Distance from the market is again significantly and positively related to adjusting planting dates adaptation option and on the other hand it is the negatively influence these farmers who are use improved crop varieties adaptation strategies to climate change. This finding shows that a one km increase in average km taken to the market distance, the probability of farmer's use adjusting planting dates to climate change increases by 8.43% at 1% significant level, hold another variable as constant. On another hand, a one km increase in average time taken to the market distance the probability of farmers' to use improve crop varieties strategies to climate change decrease by 8.96 % at 1% significance level, keeping another variable as constant.. Because if farmers are lived far away from the market distance, they would not obtain better information, experience sharing, and it is difficult farmers to buy new agricultural technologies and inputs.

*Farming experiences*

A farm experience of households is one of statistically significant explanatory variable which is measured as a substitution indicator for age, has a negative coefficient. Negative sign specified that it has negative influence in taking adaptation strategy to climate change. A one year increase in farm experience of the household head, the possibility of farmers' improved crop varieties adaptation strategy is decreases by 9.02 % at 1% significant level, keeping other variables are constant. The more experienced the farmer is, the better informed he/she is about temperature and rainfall changes in the study areas and the more he/she is likely to employ adaptation measures that reduce the impact of climate change on his/her agricultural activities..

*Agro-ecology*

The result indicated that farming in Kola significantly decreases the probability of adjusting planting dates, irrigation ,use improved crop varieties and soil and water conservation practices and as adaptation choices to climate change by 13.8% and irrigation at 5%, 28.59 and 15.23% at 1% significant level decrease respectively as compared to other ecological zones. This result shows farmers who charged in different agro ecological zone has different adaptation options to compact climate change impacts.

*Farmers-to-farmers' extension service*

Is also among the significant explanatory variable in this model. As compared to the farmers who have no access to farmers to farmer's extension service, the probability of using improved crop variety adaption methods to climate change increases by 17.2% for farmers' who have access farmers-to-farmers' extension service, keeping other variables constant. The result indicate that the frequency of extension visit has positive and significant influence on use of Adjusting planting dates which could in turn helps to reduce the negative impact of climate change. Similarly, a unit increase in extension services is likely to increase the probability of farmer to using adjusting planting dates 5 % significant level which could in turn helps to reduce the negative impact of climate change in smallholder farmers agricultural Table 1. This is due to the fact that extension services provides information on the importance of crop diversification, climate change and adaptation strategies. Farmers with more access to information and technical assistance on agricultural activities have more awareness about the consequence of climate change. Therefore, this study suggests that the availability of better climate and agricultural information helps farmers to take comparative decisions among alternative adaptation options and enable them to adapt better with changing climate.

*Soil fertility status*

Soil fertility is one of statistically significant explanatory variable which is considered and has a negatively affect improved crop varieties. Negative sign indicates that it has negative effect in taking adaptation strategy to climate change. A soil fertility quality increase of the household head land, the possibility of farmers' improved crop varieties adaptation strategy is decrease by 21.26% at significance level 1%, keeping other variables are constant. On the other hand, a soil fertility quality decrease of the farmer, the probability of farmer's drought tolerate varieties use adaptation strategies to climate change increase by 8.26% at 10% of significant level ,holding others variables constant.. Hence, poor soil fertility is assume to increase the probability of a farmer to make conservation decisions in order to adapt to climate change impacts.to make conservation decisions in order to adapt to climate change impacts.

**Conclusions**

The strategy of irrigation was positively influenced by gender, livestock holding, agricultural extension services whereas it was negatively affected by landholding and agro-ecology. Soil and water conservation practices was also positively influenced by landholding size and while it was negatively affected by agro-ecology. Improved crop varieties was positively affected by farm income and farmers to farmers extension however negatively affected by market distance, landholding size, agricultural extension services, farming experience and soil fertility status . The choice of adjusting planting dates was positively affected with market distance and farmers to farmers of the household head and negatively influenced agro-ecology. Finally, the drought tolerate varieties (base category) was positively with access to credit, landholding size, market distance, agro-ecology and soil fertility status. Generally, the result of this study provided appropriate information for policy makers and other stakeholders about the condition of awareness level of farmers for the changing climate to start o involvement. It also identified the most important choice of adaptation strategies used by smallholder farmers that need to be economized to best reacted to the existing climate change. Above all, it shows the key factors to consider during intervention in order to develop the available adaptation strategies so that promote the adaptive capability of farmers.

The level of perception of farmers to climate change has a significant effect on the level of using adaptation strategies to lessen the effect of climate change. But there are still a considerable number of farmers who did not perceive the changing climate. Therefore, emphasizing on awareness creation about the changing climate is crucial. Policy interventions aimed at justifying the adverse effect of climate change need to focus on supporting farmers to intensively use and capitalize the existing adaptation strategies: use of adjusting planting date, soil and water conservation practices, drought tolerant crop varieties, and irrigation.

Promoting for farmers' farm income is vital to secure immediate need of money for the very purpose of purchasing farm inputs and meet the costs associated with using various adaptation strategies: adjusting planting date, soil and water conservation practices use improved crop varieties, drought tolerant crop varieties, and irrigation in response to climate change. Therefore, contribute and availability of formal income providers that can be accessed with affordable interest rate need to be increased to improve farmers' financial capability.

Concerned government body such as education sectors access to education to farm household farmers to adapt climate change, Stakeholder must do like agriculture sectors facilitate farm inputs such as fertilizers and seeds to the house hold farmers for implement to climate change adaptation, Agricultural extension experts facilitate extension services to Kebeles farmers to adapt climate change adaptation or development agents strong relationship with farm households farmer by giving climate/weather information, national meteorology agency facilitate weather station site in the district farmers know/ hear climate information for implementation to climate change adaptation and Omo-micro-finance sectors access to credit to farm households farmers to adapt climate change.

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