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## RESEARCH ARTICLE

# SMALL HOLDER FARMERS ADAPTATION STRATEGIES TO CLIMATE-RELATED RISK FACTORS IN WHEAT PRODUCTION IN SELECTED DISTRICTS OF CENTRAL OROMIA, ETHIOPIA

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**ABSTRACT**

A study was conducted to identify smallholder farmers' adaptation strategies to the impact of climate change on wheat productivity and to determine factors influencing the choices of the strategies, in Arsi Zone of Oromia Regional State Ethiopia. Field survey was conducted on 196 smallholder farmers using a multistage stratified random sampling technique. Descriptive statistics and Multinomial logit (MNL) were used to analyze the data. Results from the descriptive statistics indicate that drought, flood, crop pest or disease and storm were the major climate-related risk factors faced by the sampled household farmers. The majority of the respondents (81.6 %) faced crop pest or disease followed by drought. More than 74 % of the sampled households used adaptive seed varieties, and soil and water conservation, early or late planting and increasing seed rate methods as adaptation strategies to cope with adverse effects of the risk factors on wheat production and productivity. Results from the MNL model indicated that the direction and magnitude of the determinant factors vary across adaptation strategies. On top of that, the type of risk factor households' encounter influenced the type of adaptation strategies chosen to adapt to or mitigate the effects of the climate-risk factors. Strengthening existing households' adaptation strategies through extension system appears instrumental. In this regard, awareness creation through regular trainings, extension services and mass media are vital particularly in enhancing existing adaptive practices like late or early planting, seeding rate management, provision of subsidy modalities or credits for purchasing adaptive wheat varieties, and construction of locally feasible physical structures for conserving soil and water. Above all, provision of reliable agro-meteorological information before the cropping system could help households manage appropriate adaptive strategies.



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## INTRODUCTION

The effect of climate –related risk factors (increase in temperature, increase or decrease rainfall such as drought, flooding, pests and diseases) on crop production is likely to be increasing through time because of climate change. For instance, the increase in global temperature has affected the agricultural production and the livelihood of farm households in developing countries (Mendelsohn, 2008, Di Falco, S, *et al*., 2011 and Harvey *et al*., 2014). The negative effects of climate change on developing countries' agriculture are complex. Climate change causes more negative effects on crop yields of low-income countries where adaptive capacity is low (IPCC, 2011). Agronomists have long warned that climate change would result in harsher negative effects on farms of developing countries than on developed countries (Rosenzweig, *et al*., 1994 and Mendelsohn, 2008), which is harsher particularly on drought-prone Sub-Saharan Africa (SSA). In SSA, climate change could reduce agriculturally suitable land area and rain-fed crop yields by as much as 50% by 2020 (IPCC, 2007). It alsoresults in change in optimal growth conditions for crops and increases pest incidences, which lower yields (Rowhani *et al*., 2011; Lybbert and Sumner, 2012; Jarvis *et al*., 2012; Waha *et al*., 2012).Smallholder farmers in Ethiopia are facing different types of climate-related risks, such as reduced or variable rainfall, warming temperatures, crop and livestock pests and diseases, flooding, shortage of water and soil erosion (Alemayehu and Bewket, 2017a, 2017b). Previous studies indicated that Ethiopia is one of the most vulnerable countries to climate change and with the least capacity to respond (Yesuf, M, *et al*., 2008; and Di Falco, S *et al*., 2011). The country has suffered from periodical extreme climate events, manifested in the form of frequent droughts and floods.

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According to the World Bank, the occurrences of frequent droughts and floods were found to significantly reduce Ethiopia's annual growth potential. For instance, the 1984-85 droughts reduced Ethiopia's agricultural production by 21 %, which led to a 9.7 %fall in the GDP (World Bank, 2006). In the country, long-term climate change is highly linked with changes in precipitation patterns, rainfall variability, and temperature, which could have increased the country's vulnerability to both droughts and floods. The country has suffered from periodical extreme climate events, manifested in the form of frequent drought in (1965, 1974, 1983, 1984, 1987, 1990, 1991, 1999, 2000, 2002, and 2011) and occasional flooding in (1997 and 2006), Di Falco, S, *et al*., (2011). Thus, the amount and distribution of rainfall and temperature during the growing season are decisive climatic factors with huge negative impacts on crop yields. In Ethiopia, crop production can be characterized as largely depends on rainfall combined with traditional farm technologies; uses of ox-drawn wooden ploughs with steel pipes and other time-honored farm equipment's; minimal application of fertilizers and pesticides; weak extension services; and low use of improved seeds.Depending on rainfall, small scale and poor farm households cultivate about 95% of the total area under crops in Ethiopia (Deressa, T. T., *et al*., 2008 and Meseret, 2009).

Likewise, in Ethiopia, wheat production is highly vulnerable toclimate-related risk factors. Wheat (*Triticumaestivum* L.) is sensitive to the carbon dioxide concentration in the atmosphere. Carbon dioxide is of the most important element of greenhouse gases that increases the global temperatureor cause global warming. Such rise in temperature shortens the growth period of wheat and hence, resulting in early flowering and maturing, which in turn decreases the nourishment going to the seed due to increased respiration leading to the development of immature seeds. Further increases in temperature by 1°C will lead to a potential wheat yield reduction of 7.5% (Graciela *et al*., 2003). You *et al*. (2005) reported that a 1% increase in temperature of a wheat-growing season reduced wheat yield by about 0.3%. Besides, wheat is also severely vulnerable to drought. Wajid*et al*. (2007) indicated that drought considerably reduces wheat productivity levels. Therefore, it can be argued that climate-related risk factors are a major challenge for crop production. While the voices about climate-related risk factors are getting more and more attentions, it is becoming extremely important to foresee the likely impact they will leave on farmer's main source of food and income, i.e., crop production. Due to the value of wheat as one of the major food crops in Ethiopia, copping the impacts of climate-related risk factors on wheat productivity is crucial. Adaptation strategies to these factors are believed to be important mechanisms to reduce their negative impacts on wheat production. Thus, this study identified and examined factors that determine the decision-making of smallholder farmers' of choosing adaptation strategies to the coping of the impacts of climate-related factors on wheat production in Arsi Zone, Oromia Region, Ethiopia.

## MATERIALS AND METHODS

### Description of the study area

Arsi zone is one of 21zones of Oromia regional state in Ethiopia. It is located to the southeast of the regional and national capital, Addis Ababa with a distant of 170 km to the station town, Asella. The zone is bounded by East Showa zone in the northwest, West Arsi in the west, West Hararge in the East and Bale zone in the southeast. Arsi zone consists of 25 districts and 1town administrations (CSA, 2007). The study was conducted in three selected districts of Arsi Zone. The study area is divided into three agro-climatic zones based onthe variation inaltitude. It is dominantly characterized by moderately cool (about 40 %) followed by cool (about 34 %) annual temperature. The mean annual temperature of the zone is between 20-25 $^0$Cin the lowland and 10-15 $^0$C in the central highland. Cold type of thermal zone is found in the highland areas of *Chilalo*, *Gugu*, *Onkolo* and *Kaka* Mountains. The category of moderate warm temperature is found in the low land areas of *Dodota, Amigna, Seru* and *Merti* districts. Some highland districts include *Lemu-bilbilo, Onkolo-wabe and Tiyo partially*, whereas *Hetosa and Lode Hetosa* districts mainly fall in mid altitude. The mean annual rainfall varies from 633.7 mm at *Dhera* station which is in *Dodota* district, and located at altitude of 1680 meters above sea level to 1059.3 mm at *Bekoji* station in *Lemu-bilbilo* district located at an altitude of 2760 meters above sea level.On average, the zone receives a monthly mean rainfall of 85mm and an annual mean rainfall of 1020 mm..According to the Central Statistical Agency of Ethiopia (CSA), the zone covered a total area of 19825.22 km$^2$ and consists 2,637,657 total population, of which 1,323,424 are male and 1,314,233 female (CSA 2015). The total area of wheat production covered in the zone is estimated about 188,077.15 hectare which is about 35.01% of the total area under grain crops and a total yield of 3,319,378.34 Quintals (331,937,834.00 kg). This is about 39.02% of the total grain yield in the zone (CSA, 2015).

### Sampling technique and sample size determination

A multistage stratified random sampling was employed to arrive at a household level. In the first stage, three major wheat producing districts representing the three major agro-ecologieswere randomly selected, that is, Tiyo district from highland, Hetosa district from mid-altitude and Dodota district from lowland altitude were selected as study sites.At the second stage, three farmers associations, i.e., Denkaka, ShakiSherera and DodotaAlemwere selected randomly from Tiyo, Hetosa and Dodotadistricts, respectively. In the third stage, sample farm households werefinally selected by a simple random sampling technique. The total sample size was determined according to the sampling formula provided by Cochran (1963). The sampled households were randomly selected from selected farmers associations of selected districts which themselves were selected on proportionality basis. The formula used to determine the minimum sample size with infinite population was:

$$n = \frac{Z^2 p.q}{e^2}$$

Where: n is the sample size, $Z^2$ is the abscissa of the normal curve that cuts off an area α at the tails (1 – α) equals the desired confidence level is 95%, e is margin of error (if the margin of error is 5% then e=0.05, p=0.85 which implies 85% of farm households produced wheat, and q is 1-p which is equal to q= (1-0.85) =0.15. The value for Z is found in statistical tables which contain the area under the normal curve. Based on the above sample size determination formula and 10% non-response error consideration:

$$n= \frac{(1.96)^2\,(0.85)(0.15)}{(0.05)^2} = 195.92 \cong 196+19=215$$

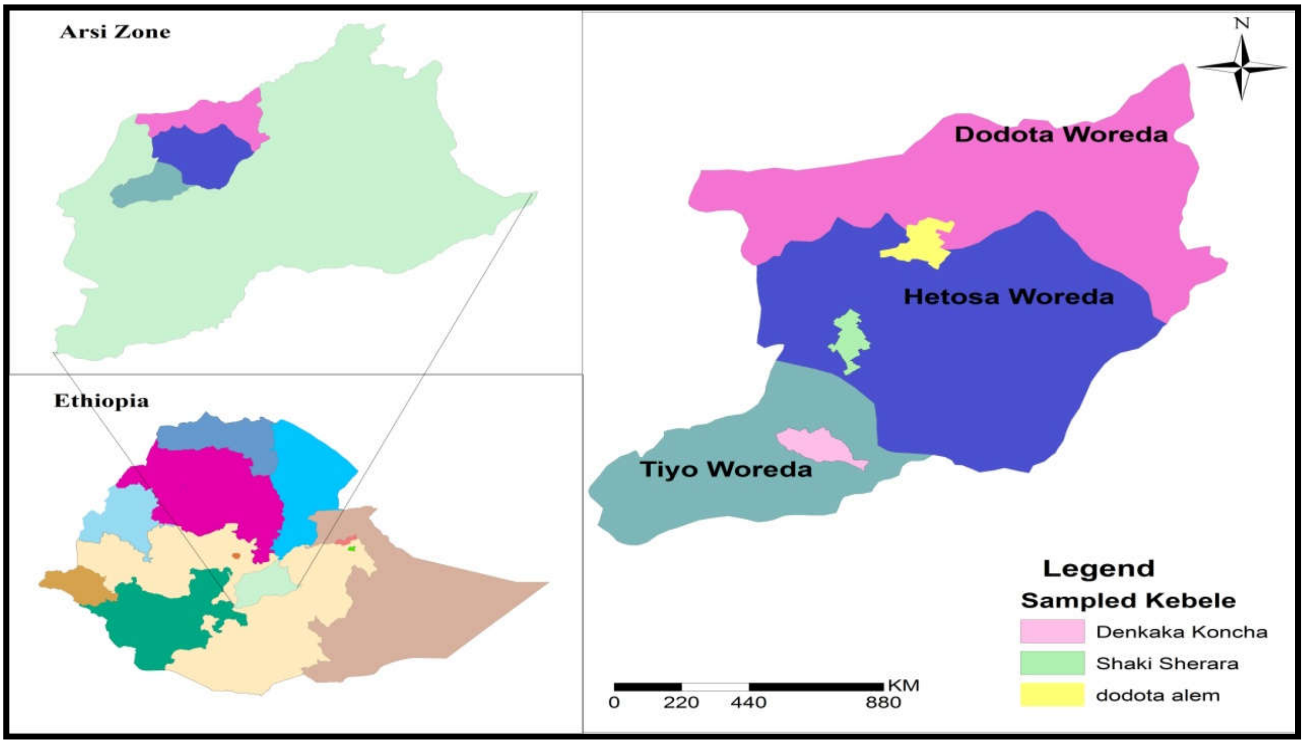



**Figure 1. Map of the study areas**

**Method of data analysis and model specification**

Descriptive statistics such as mean, percentages, frequencies, and standard deviations were used in the process of identifying and describing climate-related risk factors, choice of adaptation strategies and factors determining the decision-making in choosing the strategies. Additionally, statistical tests like significance tests, chi-square tests and independent t-tests were undertaken. STATA version 13 software package was used for the statistical computation purpose. Wald test and tests to check the presence of multicollinearity problem using Variance Inflation Factor (VIF) values and correlation matrix methods were carried out before running a Multinomial Logit (MNL). The MNL regression model was applied to model the choice of the adaptation strategies, and was estimated by using a maximum likelihood method of estimation. The advantage of the MNL model is that it allows the analysis of adoption options across more than two alternatives (Deressa, T. T., *et al*., 2008).

The MNL model can be derived from a latent model (Wooldridge, 2002). Let $Y^*$ denote a latent dependent variable (adoption options) taking on the values j (j=1, 2, …,J) for j ≥ 0 and j≤ 1. The latent variable model can be specified as follows:

$$Y_{ij}^* = Z_i \beta_j + \varepsilon_{ij} \text{ --------------------------------- } 1$$

With

$$Y_{ij} = \begin{cases} = 1 \text{ iff the net benefit from using strategy } Y_{i1} > Y_{ij}, Y_{i1} \neq Y_{ij} \\ \\ = J \text{ iff the net benefit from using strategy } Y_{iJ} > \text{any} Y_{ij}, Y_{iJ} \neq Y_{ij} \end{cases}$$

It is assumed that that the covariate vector $z_i$ is uncorrelated with $\varepsilon_{ij}$, i.e.,

$$E(\varepsilon_{ij} | z_i) = 0 \text{ -------------------------------------- } 2$$

Under a multivariate normal distribution assumption, each observation records one of the J possible values for the dependent variable $Y$(in this case the adaptation strategy). Under the assumption that $\varepsilon_{ij}$ are independent and identically distributed, that is under the Independence of Irrelevant Alternatives (IIA) hypothesis, the latent variable model (3) leads to a multinomial logit (MNL) model (Wooldridge, 2002). For the multinomial logistic regression model, we equated the linear component to the log of the odds of a $j^{th}$observation compared to the $J^{th}$ observation. That is, we considered the $J^{th}$ category to be the omitted or baseline category, where logits of the first $J-1$ categories are constructed with the baseline category in the denominator (Czepiel, 2007). That is;

$$\log\left(\frac{\pi_{ij}}{\pi_{iJ}}\right) = \log\left(\frac{\pi_{ij}}{1-\sum_{j=1}^{J-1}\pi_{ij}}\right) = \sum_{k=0}^{K} z_{ik}, where\ i = 1,2,....N, and\ j = 1,2,..,J-1 \text{ ----- } 3$$

Solving for $\pi_{ij}$ we have;-

$$\pi_{ij} = \frac{\exp(z_i\beta_j)}{1+\sum_{h=1}^{J-1}\exp(z_i\beta_h)} \text{ ---------------------------------- } 4$$

The parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent (response) variable; estimates do not represent neither the actual magnitude of change nor probabilities (Schmidheiny, 2007). Differentiating equation (4) with respect to the explanatory variables provides marginal effects of the explanatory variables. The derivation of the equation is given as:

$$\frac{\partial p_j}{\partial z_k} = P_j\left(\beta_j - \sum_{j=1}^{J-1}(P_j\beta_j)\right) = P_j(\beta_{jk} - \beta_k) \text{ -------------------------- } 5$$

The marginal effects or marginal probabilities are functions of the probability itself and measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable from the mean. Thus, the marginal effect of an independent variable zkon the choice probability for alternative strategy j depends not only on the parameter$\beta_{jk}$but also on the mean of all other alternatives i.e. $\beta_k = \frac{1}{\sum_{j=1}^{J-1}\beta_{jk}}$ (Deressa, T. T., *et al.,*2008).In our case*J* is the reference or baseline category for comparisons. It represents the choice of farm households not to use any crop adaptation strategy. Therefore, a positive parameter $\beta_{jk}$means that when an independent variable $z_k$ increases by one unit from the mean, the relative probability of choosing adaptation strategy *j* increases relative to the probability of choosing alternative *J.* That is, the increase by a unit of the independent variable $z_k$ from its mean value will increase the probability of choosing adaptation strategy *j* by $\beta_{jk}$ relative to the baseline category J (not to use any adaptation methods). The parameters $\beta$ can be estimated by maximum likelihood (Czepiel, 2007).

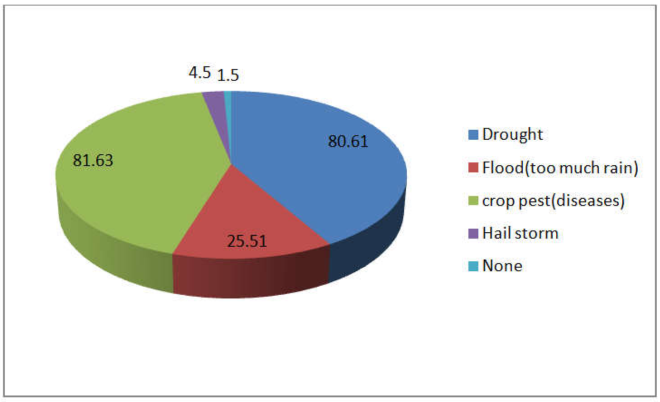



**Figure 1. Proportion of Respondents by type of Climate change related risk factors faced**

The result of obtained from survey, only 1.5% of the sampled farmers did not face any type of climate change related risk factor in the last production season. About 81% of the sampled households faced at least drought and/or crop pest/disease, whereas the minority (about 5%) faced at least hail storm in the last production season.

**Table 1. Definition of explanatory variables used in the multinomial logistic model**

| Explanatory variables | Variable description |
|---|---|
| | Climate variables |
| Frequency of occurrence of droughtin the last 10 years | Number of times a householdperceived droughtin the last ten years |
| Risk factor1 (drought) | Household's perception of facingdrought of the last croppingseason: dummy takes value 1if 'Yes' or0 otherwise |
| Frequency of occurrence of floodingin the last 10 years | Number of times a householdperceived flood in the last ten years |
| Household's perception to flooding occurrence | Farmers´ perception that they faced flood in the last production season: dummy takes value 1if 'Yes' and 0 otherwise |
| | Household orhousehold head characteristics |
| Family sizeof a household | Total family size (men equivalent) |
| Educational level of a household | Household head'seducation level (categorical) |
| Main occupation of a household | Dummy: 1 = Farming and 0 Otherwise |
| Sexof a household head | Dummy: 1 = Male and 0 Otherwise |
| Marital status of a household | Dummy: 1 = Married and 0 Otherwise |
| Income of a household | Household's total income per year in ETB[1] |
| Asset of a household | Household's total material assets in ETB |
| Livestock ownership of a household | Household's livestock holding size, measured in TLU |
| Plot characteristics | |
| Soil or plot slope | Household'sweighted average of all crop farms: 1=Flat, 2 = Medium slope, and3 = Steepy |
| Soil fertility status | Household'sweighted average of all crop farms: 1= Fertile,2 = Medium, and 3= Poor |
| Crop farmland size | Total crop farms a household owned (in a hectare (ha)) |
| Experience of grown wheat | Numberof years a householdgrown wheat |
| | Institutional and infrastructural variables |
| Access to local market | Walking distance in minutes to input and output market |
| Confidence of household in the skill of extension workers | Dummy: 1= Complain and 0 Otherwise |
| Constraints to accessing credit | Dummy 1= Faced constrain and 0 Otherwise |
| | Social capital (social network) |
| Kinship | Number of friends/ relatives to ask support in time of needs |
| Friends or relatives in government offices | The availability of friends/relatives in government offices Dummy: 1 = Yes and 0= No |
| Membershipof any kind in farmer groups | Dummy: 1= Member and 0 Otherwise |

Source: Survey result, 2016

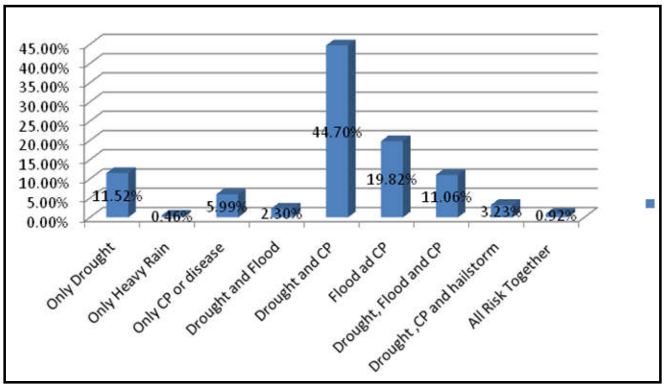
## RESULTS AND DISCUSSION

### Climate Change Related Risk Factors

The climate change related risk factors in study are based on asking farmers if they faced climate change related risk factors and which risk factors they faced in the last production season. Accordingly, farmers in the study areas faced four types of climate change related risk factors in the last production season. The risk factors are drought, flood, crop pest / disease and hail storm. Figure 1.

The third risk factor indicated by the number of households faced was flood. Consequence indicates that the sampled farmers who experienced some climate change risk factors were also exposed to multiple risk factors. While there were farm households who faced only one risk factor and others faced multiple risk factors (Figure 2). As presented in figure 2 below, out of the total households who faced climate change related risk factor, about 82.03% faced more than one risk in the last production season. While the rest 17.97 % faced only one type of climate change related risk factor, from those households only one type of climate change risk factor; about 64.10 % faced by drought, and about 2.56% faced by Heavy rainfall. Out of the total sampled taken farmers only 11.52%

faced only drought. The result farther indicated that, from those households who faced more than one risk factor the majority faced drought and crop pest together, while the minority faced drought and flood together. From total farm households that face crop pests/diseases sampled, about 5.99% experienced crop pests/diseases without facing any other risk factors in the last production season and also about 97 household crop pests/diseases plus drought which is 44.70%.




Source: Survey result, 2016

**Figure 2. Composition of risk factors**

Generally, the results indicate that drought and Crop Pest are the two major climate change related risk factors faced by farmers in Arsi Zone. In fact other studies also show that in Ethiopia drought and flood are the most serious climate change related risk factor faced by the majority of smallholder farms. For instance Bryan, *et al.,* (2009) showed that in Ethiopian Nile basin the majority of the sampled households faced frequent droughts and floods in five years.

### Adaptation strategies used to cope with the risk factors

Regarding to cope up climate change risk factors faced were used wheat crop adaptation strategies. The indentified and selected wheat crop adaptation strategies used by farm households are planting fitting seed varieties, early/late planting method, increasing seed rate and soil and water conservation methods (Figure 3). Wheat yield related strategies used by more than 74.48% sampled farmers from the total sampled. However, farmers also used other strategies that are not related with yield including migration, transforming from crop to livestock agriculture and shifting to non-farm activities and did not used any adaptation strategies, which together accounts for less than 25.52% of households that used adaptation strategies.

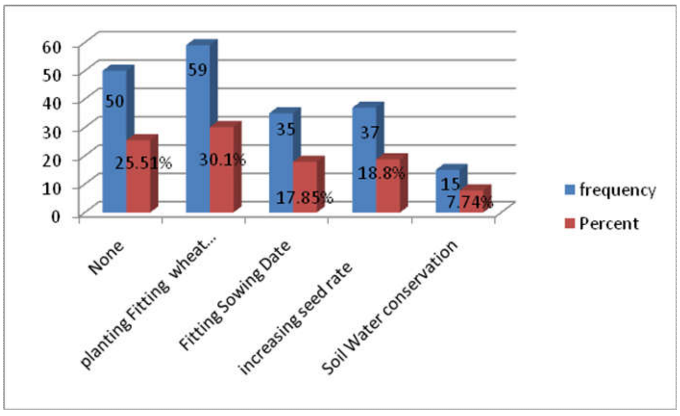
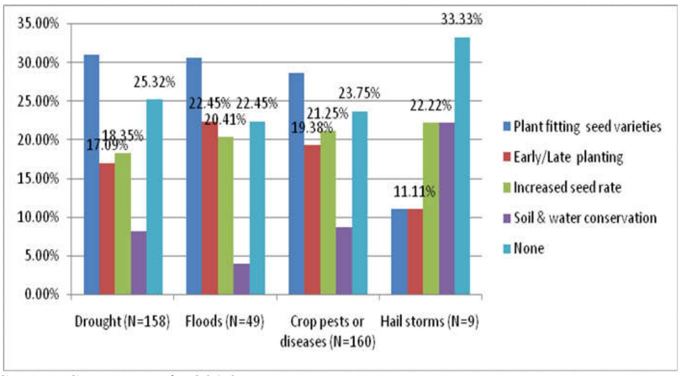



**Figure 3. Adaptation strategies used to cope with the risk factors**

As the purpose of this study is to analyze factors that affected the decision of farmers to use yield related strategies and the impact of these strategies on households′ wheat productivity, those farmers that used non-yield related strategies are considered as non-adapters in this study. Figure 3 shows that majority (about 25.51 %) of farm households who faced environmental risk factors did not take any crop adaptation strategy in any of their cropped plot. The most commonly practiced method of wheat crop adaptation in the study areas was planting fitting wheat varieties (drought /Heavy Rainfall Tolerant) whereas use soil water conservation adaptation method least practiced among the major adaptation methods (Figure 3). This could indicate that farm households had a better access to use fitting seed varieties, or it may be also due to the fact that farmers thought that practicing this method of adaptation is better in terms of maximizing their crop yields. Similarly, the reason for having less farmers practicing soil water conservation as a crop adaptation strategy could be the higher labor demand associated with constructing and maintenance of soil and water conservation structure. Others also for not using increased seed rate as a crop adaptation strategy could be the higher costs associated with buying more seeds. This could be due to farmer's expectation that use of increased seed rate as a method of crop adaptation could result in less benefits in terms of maximizing crop yields. The results also indicated that a single type of crop adaptation strategy could be used to cope up with more than one environmental risk factor. All crop adaptation strategies were used to cope with all types of identified climate change risks (Figure 4).




Source: Survey result, 2016

**Figure 4. Risk factors and adaptation strategies (% responses)**

However, the popularity of practicing a specific crop adaptation strategy to cope with the adverse effects of a given climate change risk factor varied based on the type of risk factor faced. The most widely used strategy to cope with the effect of drought was plant fitting seed varieties method (31.01%), followed by use of Early/Late planting method (17.09%). Soil and water conservation method was used only by 8.23% percent to deal with the problem of drought in crop production (Figure 4). This may indicate that farmers had relatively better access to inputs required to practice fitting wheat seed varieties methods. It may also indicate that farmers had expected that these methods are relatively more effective in terms of minimizing the negative effect of drought on their crop yields. Planting fitting seed varieties was also among the very popular in militating against the adverse effects of heavy rainfall/floods among the surveyed households. The strategy least practiced to cope with the negative effects of flood on crop yields was also soil and water conservation. On the other hand, majority of the cases that experienced crops pests or diseases used plant fitting seed varieties as an adaptation strategy to this problem followed by planting increased seed rate method which implies that incase of the lack of access to fitting wheat seed varieties farmers preferred to use Increasing seed method in which farmers expects these methods are relatively more effective in terms of minimizing the negative effect of crops pests or diseases on their crop yields. Finally, Increasing seed rate and soil and water conservation were the most popular strategy to combat the hail storm problem among the surveyed households, followed closely by planting wheat seed varieties and early/late planting and planting pest/disease tolerant wheat varieties (Figure 4). Generally, there is limited use of soil and water conservation method as adaptation strategies across all the climate change risks among the surveyed households.

The response rates of farmer households to climate change related risk factors vary based on the type of risk factors faced. Despite the fact that crop pests or diseases followed by drought were the most popular climate change risk factors. The results showed that farmers those faced drought had the highest number of cases reporting that they had no crop adaptation strategy towards this risk i.e. over 25% (Figure 4).

**Sample households' characteristics**

The econometric models developed and testedhelped the identification of the key explanatoryvariables (Table 2). These independent variables were categorizedinto climate-related risk factors, household characteristics, farmor plot characteristics, institutional and infrastructural factors and social capital factors. These were the variables, which influenced the decision of households to or choose a givenadaptation strategytoabate the impacts of the climate-related risk factors on wheat production. Table 2 depicts the mean value of an independent variable along with their respective value of standard deviation

The climate variables considered in this study were incidences of droughts and floods inthe past ten cropping seasons(Table 2). Accordingly, about 80 % and 54 % of the sampled households encountered droughtand flood, respectively. In the last ten years,the average frequency of occurrence of drought and flooding were 2.4% and 1.38%, respectively. These variables are important as they help give comprehendible signs of climaticrisksat farm level. They are especially instrumental in determining the yield ofa rain-fed wheat production in the areas. The descriptive statistics result showed that there were remarkable differences between the average formal education, experience, income, total asset and livestock holding among the farming households. The average formal education level of household heads ranged fromgrade five to eight. Household heads with higher educational level had a better awareness about climate-related risk factors for decision-making tochooseappropriate adaptation strategies. The average annual income from other activities[1]of households was about 14,207.93 ETB. Households with more annual income from other activities appeared tohave the financial capacity required to choose seasonally appropriate adaptation strategies. The average asset of households was about 18,162.40ETB. The average livestock holding size measured by Tropical Livestock Unit (TLU) was about six. The disparity in the average asset and livestock holding size among households showed the significance of wealth in choosing an adaptation strategy to respondingandlessening the impact of the risk factors on wheat production.

Farmland characteristics (slope, soil fertility, soil depth, holding size and location)were foundto vary among households and were important in choosing adaptation strategies against the impacts of the risk factors on wheat production. Consequently, the weighted average were taken for plot slope, soil fertility and soil depth. The weight was calculated based on the size of each crop plot.

**Table 2. The summary statistics for seventeen independent variables**

| Explanatory variables | Total sample size | |
|---|---|---|
| | Mean | Stdev |
| Climate variables | | |
| Frequency of droughtoccurrence in the last 10 years | 3.55 | 2.41 |
| Risk factor1(drought) | 0.8 | 0.39 |
| Frequency of heavy rainfall or floodingin the last 10 years | 1.38 | 0.54 |
| Household's perception to flooding occurrence | 0.54 | 0.21 |
| Household head variables | | |
| Family sizeof a household | 2.76 | 1.11 |
| Education level of a household | 2.89 | 1.78 |
| Main occupation of a household | 0.97 | 0.16 |
| Sex of a householdhead | 0.95 | 0.198 |
| Income of a household in ETB | 14207.93 | 11413.24 |
| Asset of a household | 18162.4 | 12973.95 |
| Livestock ownership of a household | 5.83 | 4.56 |
| Plot characteristics | | |
| Soil/ plot slope | 1.2 | 0.6 |
| Soil fertility status | 2.26 | 0.84 |
| Crop farmland size | 1.95 | 1.64 |
| Household experience in growing wheat | 22.37 | 11.23 |
| Institutional and infrastructural variables | | |
| Access to local market | 23.62 | 23.55 |
| Confidence of a householdin the skill of extension workers | 0.6 | 0.49 |
| Constraints to access to credits | 0.39 | 0.18 |
| Social capital (social network) | | |
| Kinship | 13.13 | 10.62 |
| Membership of any kind of farmer group | 0.84 | 0.37 |

Source: Survey result, 2016

[1]Activities other than wheat production

Accordingly, the descriptive statistics showed that there was a remarkable difference in the weighted averages of soil depth between farm households. The category of the weighted average of soil depth of farm households was ''deep''. The implication is that the deeper the soil of a crop-farm, the less the interest of household to grow a crop on the crop-farm. The average farmland ownership of the households were about 1.95 ha and the category of the weighted average of soil fertility of farm households was ''medium''. Institutional and infrastructural factors such as access to meteorological information, input and output market, agriculture extension and credit were found important in the production of wheat. Results from the descriptive statistics showedprominentvariances of these variables among households. not to use the extension services. Households' access to a credit facility was found to constrain the productivity of wheat production. Accordingly, households responded "Yes" for the question "did you face credit constraint?" accounted about 18%. Lacking access to a credit facility, which is an institutional and infrastructural factor, influenced the capacity of households to adopt among the available adaptation strategies to mitigate the impacts of the risk factors on the wheat production. Social capital (social network) such as the availability of friends or relatives in government offices, the number of friends or relatives to rely on for support in times of need, membership to any farmer groups in the village were found to determine the capacity of households to make choice among available adaptation strategies(Table 2).

**Table 3. Parameter estimates of the multinomial logit model**

| Dependent variables (Adaptation Strategies) | Methods 1; Planting fitting wheat seed varieties Coef. Standard error | Method 2;Early /Late Planting Coef. Standard error | Method 3 Increasing seed rate method Coef. Standard error | Method 4;Soil And Water Conservation Coef. Standard error |
|---|---|---|---|---|
| Explanatory variables | | | | |
| Climate variables; | | | | |
| Past Drought Incidence | -0.580** | 0.023 | 0.116 | 0.251 |
| | 0.246 | 0.1902 | 0.1852 | 0 .210 |
| Current Drought incidence | 1.464* | -0.424 | -1.29 | 0.865 |
| | 0.835 | 0.947 | 0.843 | 1.49 |
| Past Heavy Rainfall/flood | 0.225 . | -0.551 | -0.083 | -0.085 |
| Incidence | 0.168 | 0.393 | 0.187 | 0.526 |
| Distance to Input Market | -.002 | 0.026** | 0.0018 | -0.080** |
| | .011 | 0.012 | 0.0119 | 0.041 |
| Wheat Experience | 0.028 | -0.007 | 0.045 | 0.081 |
| | 0.025 | 0.0324 | 0.029 | 0.055 |
| Confidence | 0.257 | 0.527 | -0.210 | -0.715 |
| | 0.457 | 0.596 | 0.513 | 0.831 |
| Access to Credit | -0.418 | -0.464 | 0.149 | 0.579 |
| | 0.615 | 0.772 | 0.662 | 1.47 |
| HH head Education | -0.036 | -0.136 | -0.125 | 0.286 |
| | 0.138 | 0.171 | 0.169 | 0 .285 |
| No of family Members | -0.321 | -0.065 | 0.340 | -0.914 |
| | 0.239 | 0.312 | 0.271 | 0.458 |
| Kinship | 0.024 | 0.042 | -0.115*** | -0.202** |
| | 0.025 | 0.030 | 0.039 | 0.085 |
| TLU SUM | 0.013 | -0.239** | -0.248** | 0.1384 |
| | 0.086 | 0 .1035 | 0.1117 | 0.157 |
| Total Asset | 0.00003 | 0.000084*** | 0.00006** | 0.00005* |
| | 0.00002 | 0.00002 | 0.00002 | 0.00003 |
| Income from non wheat | 0.00002 | -0.00007** | 0.00003 | -0.00001 |
| production activities | 0.00001 | 0.000029 | 0.00002 | 0.00005 |
| Total Land Owned | -0.2184 | 0.256 | 0.036 | -1.049 |
| | 0.189 | 0.263 | 0.239 | 0.620 |
| Soil fertility | 0.010 | -1.056*** | -0.332 | 0.569 |
| | 0.302 | 0.402 | 0.327 | 0.574 |
| Soil Slope | -0.126 | 0.775 | -0.246 | -1.090 |
| | 0.509 | 0.4872 | 0.512 | 0.8343 |
| Cons | -0.236 | 0.872 | 1.283 | 0.729 |
| | 1.61 | 1.77 | 1.838 | 3.23 |

Note:

| | | | |
|---|---|---|---|
| Base category No adaptation | | | |
| Number of observations | 196 | Prob > chi2 | 0.0000 |
| LR chi2(64) 156.15 | | Pseudo R-Square | 0.2605 |
| Log likelihood -221.59 | | | |
| Notes: *, **, *** = significant at 1%, 5%, and 10% probability level, respectively | | | |

Source: Survey result, 2016

About 69% of the sampled households had access to agrometeorological information for the previouscropping seasons. The average walking distance to the nearest agricultural input and output market was about 24 minutes. Household heads'confidence to the skills of agriculture extension workers was about 60%. Such a confidence was found to influence the decision-making of households to useor The average availability of friends or relatives in government offices (1= had friends or relatives in government offices is the reference category[2]) was about 75%. The average number of friends or relatives to rely on for support in times of need was

[2] Reference or baseline category = none (0)

about 13. The average membership to any farmer group in the village (1= member is the reference category) was about 84%.

### Econometric results and analysis

The results of MNL model measures whatfactors influence farmers' choice of adaptation strategies in the study area. The MNL adaptation model was run to restructure choices and identifythe significance levelof the parameter estimates. The results of MNL regression model showed that the likelihood ratio of $ch^2$ statistics (LR chi-square (64) = 156.15)was highly significant ($P < 0.0000$), indicating the model to have a strong explanatory power so that the estimated coefficients should be compared with the base category of no adaptation (see details in Appendix I).Table 3 presents the MNL results along with the levels of statistical significance. As indicated earlier, the parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent (response) variable: estimates do not represent actual magnitude of change or probabilities. Thus, Table 4 depicts the marginal effects from the MNL, which measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable, are reported and discussed. In all cases the estimated coefficients should be compared with the base category of no adaptation.

### The main determinant factors affecting the choose of different adaptation strategies to climate risk factors

### Drought incidence in last ten years

Frequency of drought occurrence in the last ten years was found to have negative and significant ($p < 0.05$) influence. As the farmers face one additional year of drought risk in the past ten years, the probability of farmers to choose ''planting fitting wheat varieties''as a coping strategy decreases with 10.7%. This result is in line with previous findings of Deressa, T. T., *et al.* (2008); Ajibefun and Fatuase (2011); Nhemachena and Hassan (2007); Maddison (2006) and Ishaya and Abaje (2008), whichreported that as the households' experience to drought occurrences increases, the probability tochoose costly adaptation strategies decreases. For instance, experienced households do not choose adaptive wheat seed, for it is expensive and not easily available timely for a specific cropping season.

### Drought incidence of the last cropping season

The previous croppingseason's drought incidence had positively and significantly ($p < 0.10$) influenced the decision of house holds to use adaptive wheat seed varieties. As the frequency of drought occurrence in the previous cropping season increased, the probability of households to choose and

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

| Dependent variables (adaptation strategies) | Methods 1:Planting fitting wheat seed varieties.(coefficient/ standard error) | Method 2: Early or late planting (coefficient/ standard error) | Method 3: Increasing seed rate method. (coefficient/ standard error) | Method 4:SWC (coefficient/ standard error) |
|---|---|---|---|---|
| Explanatory variables | | | | |
| Climate variables | | | | |
| Past drought incidence | -0.1066*** (0.0367) | 0.017 (0.017) | 0.033* (0.018) | 0.016** (0.007) |
| Current drought incidence | 0.303*** (0.1162) | -0.068 (0.0836) | -0.21** (0.084) | 0.038 (0.061) |
| Past heavy rainfall or flood incidence | 0.061** (0.026) | -0.061 (0.037) | -0.004 (0.022) | -0.0015 (0.022) |
| Distance to input market | -0.0003 (0.0016) | 0.003*** (0.001) | 0.0006 (0.0012) | -0.0037** (0.001) |
| Wheat experience | 0.0022 (0.0034) | -0.0033 (0.0029) | 0.0035 (0.002) | 0.0027 (0.002) |
| Confidence | 0.042 (0.0675) | 0.054 (0.054) | -0.039 (0.054) | -0.036 (0.034) |
| Access to credit | -0.067 (0.092) | -0.0405 (0.070) | 0.039 (0.070) | 0.032 (0.0632) |
| HH head education level | 0.0001 (0 .0198) | -0.011 (0.0153) | -0.013 (0.018) | 0.015 (0.011) |
| No of family members | -0.054* (0.0326) | 0.002 (0.027) | 0.067** (0.026) | -0.039** (0.018) |
| Kinship | 0.0098*** (0.0034) | 0.007*** (0.002) | -0.013*** (0.003) | -0.0081** (0.0034) |
| TLU sum | 0.018* (0.011) | -0.019** (0.008) | -0.026** (0.011) | 0.010* (0.0063) |
| Total asset | -7.73e-07 (2.99e-06) | 5.56e-06*** (1.70e-06) | 3.41e-06* (1.93e-06) | 8.65e-07 (8.33e-07) |
| Income from non wheat production activities | 5.57e-06** (2.59e-06) | -8.78e-06*** (2.67e-06) | 5.07e-06 ** (2.17e-06) | -8.43e-07 (2.45e-06) |
| Total land owned | -0.034 (0.0269) | 0.040* (0.024) | 0.019 (0.025) | -0.045* (0.027) |
| Soil fertility status | 0.044 (0.043) | -0.103*** (0.0348) | -0.022 (0.032) | 0.036 (0.023) |
| Soil slope | -0.024 (0.075) | 0.097** (0.039) | -0.030 (0.051) | -0.049 (0.033) |

Note: Standard errors provided in parentheses;*, **, *** = significant at 1%, 5%, and 10% probability level, respectively.
Source: Survey result 2016

use adaptive wheat seed varieties increased by 30.3%, keeping other variables constant. This is in line with the result of Kurukulasuriya and Mendelsohn (2007).

**Distance to input and output market**

Distance to input andoutput market was significantly ($p < 0.05$)and positively affected the probability of households to choose seasonally appropriate sowing date (early or late planting).A one additional minute walking distance from residence to market places for buying inputs or selling outputs, increases the probability of households to choose seasonally appropriate sowing date by 0.3 %, keeping other variables constant. As the distance from residence to market place increases, the probability to access information decreases. Households use market places for information sharing, thus, an increase in distance is an obstacle for getting new information, buying inputs (such as fertilizers, adaptive seed varieties, new agricultural technologies or practices, agro meteorological information, etc.) and selling outputs (such as grain, livestock, poultry, vegetable, etc.). This result is line with the result of (Maddison 2006; Nhemachena and Hassan 2007) distance to market places affect access to new farm technologies and all other information. The result of MNL depicted a negative and a significant ($p < 0.10$) association between distance from residence to input and output market, and soil and water conservation managements. A one-minute increase in walking distance to input and output market decreases the likelihood of choosing soil and water conservation strategy by 0.4 %. Hassan and Nhemachena (2008) supported this finding, where distance from residence to farm negatively and significantly influenced choosing soil and water conservation management as coping strategies.

**Householdsize**

Householdsize was significantly ($p < 0.05$) and negatively influenced household's decision to choosesoil and water conservationas an adaptation strategy. An increase in one householdmember in terms of 'man equivalent'decreases the probability of choosingsoil and water conservation strategy by 4.0 %. This may be because of the decision of household to use the extra labor to be invested on in off-farm activities generating additional income. In which (Yirga, 2007; Tagel, 2013).stated on their discussion. But the result of these research contradicts with studies done by (Croppenstedt*et al.,* 2003) which indicated that a larger household size enables the adoption of technologies by availing the necessary labor force .

**Kinship as a social capital**

Kinship was negatively and significantly influenced ''seed rate'' (at $p < 0.01$) and ''soil and water conservation methods''($p < 0.05$). An increase in one member in a household, who is willing and supporting the household in case of need, decreases the probability of choosing and using increasing ''seed rate method'' by 1.4 % and ''soil water conservation'' by 0.8%. This could be due to the traditional network for helping each other, i.e., as a house holdgets more person to rely on, the household's preference to get direct aid or support increases. Networking of various nature among members of households, relatives, and neighbors are common traditional practices among the rural communities.

**Total Livestock holding size (TLU)**

The TLU was negatively and significantly ($p < 0.05$) influenced households' decision to choose ''early or late planting'' and ''seed rate'' as adaptive strategies to climate-related risk factors. As household's TLU increase by one unit, the likelihood of the household to choose a ''seasonally appropriate sowing date'' and ''increasing seed rate'' methods as a coping strategy decreases by 1.9 % and by 2.6 %, respectively. Which indicates the increase in ownership of larger number of livestock, the economic capacity of the household to access appropriate adaptation measures for safeguarding their assets against climate-related risk factors increases?

**Total asset owned**

Total asset owned by households was positively and significantly influenced the choice of ''early or late planting'' ($p < 0.01$), ''increasing seed rate''($p < 0.05$) and ''soil and water conservation strategies''($p < 0.10$). It increased the probability households to choose ''early or late planting'', ''increasing seed rate'' and ''soil and water conservation strategies'' by 0.0006 %, 0.0003 % and 0.0001 %, respectively. Asset owned by households include radios, houses, bicycles and farming implements, for example, ox-ploughs, tractors, hoes and livestock. These assets are often used to determine the wealth status of households. A household with more domestic assets, farming implements and livestock is categorizedasa ''rich'' household as compared to a household with lower endowment of these assets. A household may also sell some of the assets that would increase the adaptability to the impacts of climate-related risk factors such as a water pump for irrigation farming. Such a strategy would could alsoimprove household's livelihood and reduce vulnerability to the climate-related risk factors. Therefore, ownership of assets such as farming implements are important inputs in agriculture in influencing household's productivity (Ajuye, 2010, Shiferaw B, 1998).

**Other income from non-wheat production**

Other income from non-wheat farm activities had negatively and significantly ($p < 0.05$) influenced households decision to choose ''early or late planting method''. A one Birr increase in the income of a household from non-wheat activities decreases the probability of choosing appropriate sowing date by 0.0009 %. This is because as households have access to other source of income from non-wheat productions activities they prefer to spent their time on that activity and rather they chooses non wheat adaptation strategies or decides not to adopt to climate adaptation strategies related to wheat yield. Thus the result is in line with the result of (Deressa, T. T., et al., 2009 ) which showed Nonfarm income showed a negative relationship with the adoption of soil conservation practices and the use of different crop varieties, although these results are not statistically significant and also (Debalke, N. M. 2014). Showed that Farmers who have nonfarm income are supposed to have nonfarm job which could possibly be a measure they took to climate change. If that is so, it will affect negatively the probability of taking some other adaptation measures.

**Soil Fertility**

Soil fertility was the other explanatory variable that was negatively and significantly ($p < 0.01$) influenced the decision to choose adaptation strategies to climatic risk factors. Accordingly, as the weighed mean fertility level of a farm increases from ''poor fertility'' level to ''medium fertility'' and to ''very fertile'' the probability of choosing ''appropriate sowing date'' method decreases by 10.4%.

**Conclusion and Policy implications**

The study analyzed the factors affecting the choice of adaptation methods to climate change based on a cross-sectional survey data collected during the 2015/2016 agricultural production year in selected districts of Arsi Zone of Oromiya Region. As main conclusion, There are significant factors that affect adaptation strategy preferences of farmers. Farmers' preference for the adaptation strategies is sensitive to Climate variables such as farm frequency of facing drought in the last ten years and facing drought in the last production session; household size ,Total Livestock holding , Total asset owned by the household and income from non wheat production activities And Institutional factors like Distance to input and output market and Farm characteristics like Soil fertility are also significant factors influencing households' preference for the adaptation strategies. Based on the findings, the following policy implications are arrived. Strengthening efforts to enhance the farmers' adaptive capacity to climate change is an important policy measure that should be considered. Encouraging investment at local level on the barriers to adaptation is also a good policy option. For instance, developing good information system among farmers, fostering research and development on wheat production specially focusing on improved seed development and promoting use of soil and water conservation are suggested intervention measures. The finding confirms the important roles of research and developments in fitting wheat seed varieties suitable to the area and the changing climatic conditions rather than sticking on common local varieties that frequently fail to meet the farmers' needs. Therefore, policies or programs aimed to reduce climate change impacts need to encourage investments on soil conservation, and researches on fitting wheat Varieties development and studying on sowing date and other agronomic practices in relation to climate change. Supporting and training farmers on soil conservation measures, and changing planting dates can improve adaptation practices to climate change. Additionally, designing programs to increase the farmers' education level is an important policy measure in enhancing adaptation to climate change and thus reduce its impact on the farmers. In addition to its role of delivering knowledge, education can create opportunities for the households to gather information on new technologies or methods of production, better information on climate change and farming practices that suit to it.

Furthermore, programs that can increase farm income of households such as better supply of inputs at fair price, and creating better access to markets and transportation facilities are suggested as policy measures. Promoting investments to create job opportunities to raise farmers' nonfarm income is also suggested to enhance farmers' capacity. Better access to agricultural extension services for farmers has the potential to increase farmers' awareness of changing climatic conditions and suitable adaptation responses to it. Therefore, a policy with the objective of enhancing farmers' adaptation to climate change should take in to account the significant roles of agricultural extension services and climate forecast information on the farmers' practices of climate change adaptation. It, therefore, argued that information on the prevailing and forecasted climate is very helpful especially for subsistence farmers who focus on growing crops and can't afford to exercise irrigation or soil conservation, because subsistence farmers are more likely to vary planting dates and diversify crops than changing to different crops or using expensive adaptation technologies such as irrigation and soil conservation. Hence, promoting less-costly adaptation options (such as multiple cropping, changing crop variety, changing planting dates etc) among smallholder farmers could have the potential to positively enhance adaptation to climate change by subsistence farmers. Generally, concerned government bodies, meteorological departments, and agricultural offices should play important role in raising farmers' awareness of the prevailing and expected changes in the climate through proper mechanisms that are easily accessible to the farmers such as extension services, local medias, social groups such as edit, farmers' gatherings, and input and output traders.. Finally, further researches and developments specific to each agro-ecology are suggested, and they need to move towards making farmers more resilient to damaging changes in climate in their wheat Yield.

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