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Farmers' Perception of Climate Change and Variability and It's Implication for Adoption of Climate-Smart Agricultural Practices

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The main purpose of this study was to analyze factors determining the smallholder farmers' perception of climate change and variability and it's implication for adoption of climate change-smart agricultural practices. The study was conducted in three distinct agro-ecologies in Geze Gofa Woreda in Gamo Gofa zone, southern Ethiopia. A multi stage sampling procedure followed to select sample respondent households and the total sample size of the study was 138 households. This study employed both qualitative and quantitative methods of data collection. Primary data were collected by using semi-structured interview schedule, focus group discussion (FGDs) and key informant interviews. Logistic regression model was used to estimate household demographic, socio-economic, institutional and geophysical factors that determine the farmers' perception of climate change and variability in the area. The results indicated that about 88.73% of farmers believe that temperature in the district had become warmer and over 90% were of the recognized that rainfall volume, pattern , distribution and timing had changed, resulting in increased frequency of drought. From the findings of the logistic analyses, the local socio-economic, institutional and agro-ecological and the information on weather and climate were significant in determining the likelihood of a good perception and knowledge of climate change and variability. To enhance rural farmers' awareness and adoption of climate change adaptation techniques, more focus should therefore be given to socio-economic (farm experience, education and training, access to weather related information household size, wealth, land ownership) factors as suggested by model results. So, effective communication, active community involvement and considering socio-cultural factors such as religious practices and rituals could be areas of policy implication of the study. Though the majority of the responders perceived climate change 62.56 percent of the total respondents adopted climate change-smart agricultural practices such as while the remaining 37.5 percent had not adapted any climate change-smart agricultural practices. This could imply that though perception is the frontline prerequisite sequentially for adoption of climate change-smart agricultural practices decisions, it is not cure-all alone.

Key Words: climate change, climate change- smart agriculture, smallholder, perception

Introduction

The Intergovernmental Panel on Climate Change (IPCC, 2007) defined climate change as statistically significant variations in climate that persisted for an extended period, typically decades or longer. It includes shifts in the frequency and magnitude of sporadic weather events as well as the slow continuous rise in global mean surface temperature. Climate change is predicted to have the main impact on agriculture, economy and livelihood of the populations of under-developed world and mainly in Sub-Saharan (World Bank, 2013; UNECA, 2011). Climate change is probably the most complex and challenging environmental problem facing the world today. Global climate change is one of the most critical challenges that the international community faces at present. Climate change and its variability pose severe risk to lives and livelihoods, particularly for the worlds poorest and the most vulnerable populations due to its adverse consequences on human health, food security, economic activities, natural resources and physical infrastructure (FAO 2014; IPCC, 2007). Of all the sectors of any economy, agriculture being the main source of providing livelihoods to majority of the rural households is extremely vulnerable to climate change. The extent of vulnerability depends, along with exposure, sensitivity and upon adaptive capacity of a household (IFAD, 2010). Africa is one of the most vulnerable continents to climate change and climate variability where the situation is aggravated by the interaction of multiple stresses, occurring at various levels, and low adaptive capacity (Boko *et al*., 2007; Sarr, 2012).

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The agriculture sector is the backbone of the economies of most of the developing world, employing about 60 percent of the workforce and contributing an average of 30% gross domestic product (GDP) in sub-Saharan Africa (World Bank, 2011; Williams, et al., 2012; Williams, 2014). Climate change with expected long-term changes in rainfall patterns and shifting temperature zones are expected to have significant negative effects on agriculture, food and water security and economic growth in Africa; and increased frequency and intensity of droughts and floods is expected to negatively affect agricultural production and food security (DFID, 2004). For instance, the recurrent droughts in many African countries have demonstrated the effects of climate variability on food resources (Stanturf *et al.*, 2011). The Continent is particularly vulnerable because of its ecological fragility, abject poverty, institutional weaknesses and political instability, now aggravated by climate change (Dixon *et al*., 2001; Livingston *et al*., 2011).

Agriculture in Africa must undergo a major transformation in the coming decades in order to meet the intertwined challenges of achieving food security, reducing poverty and responding to climate change without depletion of the natural resource base(FAO,2014; ACCRA,2010) .'Climate-smart agriculture'(CSA) has the potential to increase sustainable productivity, increase the resilience of farming systems to climate impacts and mitigate climate change through greenhouse gas emission reductions and carbon sequestration(FAO, 2010). Climate-smart agriculture can have very different meanings depending upon the scale at which it is being applied. For smallholder farmers in developing countries, the opportunities for greater food security and increased income together with greater resilience will be more important to adopting climate-smart agriculture than mitigation opportunities (Thornton *et al*., 2009a, 2009b and 2009c; FAO, 2010a; Lobell *et al*., 2011). There are a number of household agricultural practices and investments that can contribute to both climate change adaptation – a private benefit – and to mitigating greenhouse gases (GHGs)—a public good. For instance, a striking feature of many SLM practices (boundary trees and hedgerows, multipurpose trees, woodlots, fruit orchards, crop rotations, greater crop diversity, production of energy plants, improved feeding strategies (e.g. cut and carry), fodder crops, improved irrigation (e.g. drip), terraces and bunds, contour planting, water storage (e.g. water pans), and many more) and investments is that many of these activities also increase the amount of carbon sequestered in the soil or above ground, including agroforestry investments, reduced or zero tillage, use of cover crops, and various soil and water conservation structures(Hoerling *et al*., 2006; IPCC, 2007; IPCC, 2014). Thus, there are often long-term benefits to households from adopting such activities in terms of increasing yields and reducing variability of yields, making the system more resilient to changes in climate (Thornton et al., 2007, Jones and Thornton, 2008). Such activities generate both positive "local" (household-level and often community-level) net benefits as well as the global public good of reduced atmospheric carbon. However, adoption of many climate change-smart agricultural practices has been very slow, particularly in food insecure and vulnerable regions in sub-Saharan Africa and Southeast Asia (Jones and Thornton, 2008).

Smallholder farmers are highly vulnerable to the impacts climate change, due to their dependence on agriculture for their livelihoods, reliance on rain-fed crops and location in marginal lands (FAO, 2013)). There is a growing understanding that climate variability and change poses serious challenges to development in Ethiopia. The reason for this is that the mainstay of the Ethiopian economy is rain-fed agriculture, which is heavily sensitive to climate change and variability (Zhai and Zhuang, 2009). The country is expected to experience changing patterns of rainfall, increased temperatures leading to elevated evaporation rates, and flooding; these will in turn lead to greater levels of land degradation, transmission of infectious disease, and loss of surface and ground water potential. The poor subsistence farmers, who on average account for 98% of the total area under crops and for more than 90% of the total agriculture output (Dressa, 2007; EEA, 2008), are first line victims to the impacts of the changes in climate. It is a country with large differences across regions which are reflected in the country's climate vulnerability. The lowlands are vulnerable to increased temperatures and prolonged droughts which may affect livestock rearing. The highlands may suffer from more intense and irregular rainfall, leading to erosion, which together with higher temperatures leads to lower total agricultural production. This, combined with an increasing population, may lead to greater food insecurity in some areas (Aster, 2010; (Parry, 2007; Barrios *et al*., 2004).

Determining farmers' decision to adapt to and cope with shocks in one hand and for improving existing policies and to formulate new policies and supportive programs on the other hand; which types of farmers perceive that climate is changing is imperative to understand (FAO, 2012). Perception refers to the process of acquisition and understanding of information from one's environment (Maddox, 1995). Farmers have to perceive first that the climate has changed, and then identify useful adaptations and implement them. For farmers to decide whether or not to adopt a particular measure they must first perceive that climate change has actually occurred. Thus, perception is a necessary prerequisite for adaption (Maddison, 2006). Therefore to enhance policy towards tackling the challenges that climate change poses to farmers, it is important to have full knowledge of farmers' perception on climate change, potential adaptation measures, and factors affecting adaptation to climate change (Fosu-Mensah et al., 2010; Lobell et al., 2011). There is however, little knowledge whether farmers perceive climate change and have adopted adaptation measures. Hence, this paper seeks to explore farmers' perception and it's implication for adoption of climate change-smart agricultural practices. As to the knowledge of the researcher, no earlier study was conducted on the on the knowledge and perception, and determinants of farmers' perception of climate change and it's implication for adoption of climate change-smart agricultural practices in this study area. Hence, considering this knowledge gap, the researcher would study on the local level of smallholder farmers' perception of climate change and variability in Geze Gofa *Woreda.* Therefore, the purposes of this study were to (1) to identify farmers' perceptions on trends of local climate change and variability and (2) to identify factors influencing farmers' perception of climate change and variability in the study area.

The Study Area

The study was conducted in Geze Gofa *Woreda*, which is one of the 15 districts located in Gamo Gofa Zone, Southern Ethiopia. The administrative center of Geze Gofa district, Bulki town, is located at a distance of 251 kilometers from the Zonal capital, Arba Minchi town, and 517 kilometers south west of Addis Ababa the capital city of Ethiopia. Part of the Gamo Gofa Zone, Geze Gofa is bordered on the south by Oyda woreda , on the west by Basketo special woreda, on the northwest by Melokoza woreda , and on the east by Demba Gofa woreda . It is located approximately between coordinate 10033'06'' to 10050'24'' North latitude and 37042'36'' to 37058'24'' East longitude. Topographically, the area lies in the altitudes range of 690m to 3196m.a.s.l. As a result, the area is characterized by three distinct agro-ecological zones-Highland (*Dega*), Midland (*Woina Dega),* and Lowland (*Kola*), according to the traditional classification system, which mainly relies on altitude and temperature for classification.

The area is highly food insecure due to a combination of factors: high population density, small landholdings, low soil fertility and land degradation and rainfall irregularities. The main food crops are maize, enset, sweet potatoes, taro, teff, and yams. Enset and root crops are an important hedge against losses of the less drought-resistant maize; but need forces the poorer majority of households to cut their enset before it matures, forfeiting 2/3 of potential food from the plant. Although all wealth groups sell some crops, none makes as much as half of annual earnings from this. Better-off and middle groups earn most of their cash from livestock and butter sales, whilst casual work is main source of cash for the poor. There are two (bi-modal-belg and meher) distinct rainy seasons: the smaller one is the *belg*, from March to May. The main rains are in the *meher* season from July to September. The maize cycle straddles both seasons, whilst teff is a shorter cycle crop depending only on the *meher*, and therefore offers an important 'second chance' for those who can grow it when the *belg* season fails. Sweet potatoes are a particularly important crop, because two harvests per year practiced, with the principal one in the dry season of November-January; but the second, smaller harvest breaks the annual 'hunger' period in May-June. The staple foods are in order of amount consumed: maize, enset, sweet potatoes, taro, teff and yams.

The dual dependency on cereals and perennial/root crops offers some insurance against at least moderate rain failure, since maize is more susceptible than either root crops or enset to long breaks between showers and/or overall moisture deficit. Lack of grazing lands and fodder affect oxen production, so that only the better off and middle wealth group households who own all the plow-oxen are able to till the land efficiently, whilst others have to wait their turn to borrow teams of oxen. Even for middle and better off households, the high prices of inputs, especially chemical fertilizers and improved seed, coupled with a lack of agricultural credit facilities, limit agricultural productivity. In the last five years, food aid for poorer people has been a regular feature. Enset as perennial offers a store of food, but it is a store which takes four or more years to fill: when trees are cut one part of the store is evidently lost for as many years as it takes for a replacement to grow. In an area of such frequent food stress, there is a high tendency for people to go beyond the long-term sustainability of the stand of *Ense*t stems

Methodology

Sampling technique and sample size determination

This study is based on a cross-sectional household survey data from mixed crops and livestock farmers. To examine the farm-level perceptions of climate change and associated adaptation strategies in Geze Gofa *Woreda*, the selection of study area took into account three distinct Agroecological Zones (AEZs). The study followed a multi-stage sampling procedure to select sample respondent households. Geze Gofa

Woreda was purposively selected at first. The *Woreda* was purposely selected because of the frequency, intensity and duration of climate change and weather extremes related events observed and personal acquaintance with the study area. Also the Zonal weather related reports shows that almost all *Woredas* in the zone experiencing climate variability and changes. Secondly Study *Kebeles* were identified and stratified into three based on their agroecology, accordingly one *kebele* from highland agro-ecology (*Dega*), one *kebeles* from midland(Woina Dega) and one kebele from lowland agro-ecology(*Kola*) and total of three *Kebeles* (namely *Aykina Gorpha* , *Aykina Fane and Aykina Tsila*) were purposely selected to represent Highland (*Dega*), Midland(*Woina Dega*), and Lowland (*Kolla*) agro-ecological zones respectively. Finally, the sample size of the study was determined to be 138 household heads. The purpose of analysis in relation to agro-ecological differentiation is to investigate how farmers living in different agro-ecologies perceive, and adapt climate change and how different agro-ecologies are affected by climate change and variability.

Data collection

The study used both quantitative and qualitative data as well as primary and secondary data sources. Primary data were collected through semi-structured interview schedules, focus group discussions (FGDs) and key informant interviews. Structured and unstructured questionnaires were used to investigate whether farmers had noticed long-term changes in temperature, rainfall, and vegetation cover over the past 20 years. Farmers' perception of climate change is considered as an aggregated awareness about the trend of the following five climatic parameters (temperature intensity and duration, rain onset and offset, rain intensity, drought, floods) generated from the historical climate records of the research area. In the survey, farmers were asked to evaluate the temperature and precipitation trends of the area over the last two to three decades. Information was collected on demographic characteristics, physical asset, livestock and land ownership, crop management practices, access to credit and extension services, prior experience with climatic and non-climatic shocks, and perceptions about climate change. Besides collecting data on different socioeconomic and environmental attributes, the survey also included information on farmers' perceptions of climate change and adaptation methods. The surveyed farmers were asked questions about their observation in the temperature and rainfall patterns over the past 20 years.

Data analysis

Data were analyzed using the SPSS20 software. Correlation analysis was used to analyze the association between different variables. Both descriptive and inferential statistic techniques were employed to analyze the collected data. Descriptive statistics techniques such as Percentages, frequencies and means were used to represent farmers' perceived long-term changes in temperature and rainfall and barriers to the use of adaptation practices by farmers. The hypothesized explanatory variables were checked for the existence of multi-collinearity problem. When the absolute value of Pearson correlation coefficient between two variables is greater than 0.8, there is multi-collinearity problem. Logistic regression model was employed to analyze determinants of farmers' perception of climate change and variability.

Empirical model

Perceptions are context and location specific due to heterogeneity in factors that influence them such as culture, education, gender, age, resource endowments, agro-ecology, and institutional factors (Maddison, 2007; Deressa et al., 2010). The study used a logistics model to identify factors influencing farmers' perceptions of climate change, as in Ndambiri et al. (2012). In the model, the dependent variable is dichotomous in nature taking a value of 1 or 0. Although the Ordinary Least Squares (OLS) method may compute estimates for the binary choice models, certain assumptions of the classical regression model will be violated. These include non-normality of disturbances, heteroscedastic variances of the disturbances, and questionable value of R^2 as a measure of goodness of fit (Gujarati, 2003). For instance, given:

$$yi = b0 + bici + ei \qquad \{1\}$$

Where: yi = 1if a farmer perceives climate change and yi = 0 if a farmer does not, b0 is intercept, bi is parameter to be estimated, ci is variable in question, and ei is disturbance term.

This model is a typical linear regression model, but because the regression is binary or dichotomous, it is called a linear probability model (LPM). However, in a regression model, when the dependent variable is dichotomous in nature, taking value 1 or 0, use of linear probability models becomes a major problem. This is because predicted value can fall outside the relevant range of zero to one probability value. Thus, if linear probability models are used, results may fail to meet

statistical assumptions necessary to validate conclusions based on the hypothesis tested (Feder et al., 1985).
Gujarati (2003) recommended Logit and probit models to overcome the problem associated with LPM. These models use Maximum Likelihood Estimation (MLE) procedures and ensure that probabilities are bound between 0 and 1. Both logit and probit transformations estimate cumulative distribution, thereby eliminating the interval 0, 1 problem associated with LPM. The logistic cumulative probability function can be represented by:

$$P_i = F(Z_i) = \frac{1}{1+e^{-Z_i}} \quad [2]$$

where Pi is the probability that ith person will be in I -first category, Zi = b0 + bici + ei where b0 is intercept of the model; bi is model parameters to be estimated; ci are the independent variables and e represents base of natural logarithms, which is approximately equal to 2.718. In equation (2), Z can range from positive infinity to negative infinity. The probability of a farmer perceiving climate change lies between 0 and 1. If we multiply both sides of the equation (2) by 1+ e-zi we get:

$$(1+e^{-Z_i})P_i = 1 \quad [3]$$

Dividing by P and then subtracting 1 leads to:

$$e^{-Z1} = \frac{1}{P_i} = \frac{1-P_i}{P_i} \quad [4]$$

By definition; however, e^{-zi} =1/ e^{-zi} so that the equation (4) becomes

$$e^{-Z_i} = \frac{P_i}{1-P_i} \quad [5]$$

By taking the natural logarithm of both sides of equation (5), we get:

$$Z_i = \log\left(\frac{P_i}{1-P_i}\right) \quad [6]$$

In other words:

$$\log\left(\frac{P_i}{1-P_i}\right) = Z_i = \beta_0 + \beta_i \chi_i \quad [7]$$

This makes the logistic probability model.
Therefore, it can be noted that the logistic model defined in the equation (7) is based on the logits of Z, which constitutes the stimulus index. Marginal effects can also be computed to show changes in probability when there is a unit change in independent variables. Marginal effects are computed as:

$$\frac{\partial P_k}{\partial \chi_k} = \frac{\beta_k e^{-Z_k}}{\left(1+e^{-Z_k}\right)^Z} \quad [8]$$

Therefore, this logistic regression model was used to determine those factors, which influenced farmers' perception on climate change. The dependent variable is farmers' perception of climate change, a binary variable indicating whether or not a farmer has perceived climate change. It was regressed on a set of relevant explanatory variables hypothesized based on literature to have influence on perception to climate change.Using these variables, the model is specified as:

$$Z_i = (\beta_i \chi_i) + \varepsilon_i \quad [9]$$

Where: Zi is the perception by the i^{th} farmer that climate is changing, ci is the vector of explanatory variables of probability of perceiving climate change by the i^{th} farmer, bi is the vector of the parameter estimates of the regressors hypothesized to influence the probability of farmer is perception about climate change.

Definition of Variables

The major variables expected to have influence on the farmers' perception of climate change and variability are explained below:

I. **The dependent variable of the model:** in this study the dependent variable is farmers' perception of climate change and variable. So climate change and variability is about change and variability in weather and climate elements such as temperature intensity, rainfall//precipitation volume and patter, seasonal changes weather extreme events (drought, flood, torrential rain falls, heat waves, cold waves) onset and offset in rainfalls and etc. Perception is a dummy variable takes 1 when the farmers' perceive changes and variations in the weather elements and 0 otherwise.

II. **The explanatory/ independent variables:** The independent variables that are hypothesized to affect the farmers' perception of climate change and variability are combined effects of various factors, such as: household demographic e characteristics, socio-economic characteristics, institutional characteristics in which farmers operate and village level agro-ecological and biophysical conditions. Based on the review of related literatures, and past research findings, 17 potential explanatory variables were considered in this study and examined for their effect on a farmer's perception of climate change and variability

Results and Discussion

Socio-economic and demographic attributes of the sample respondents

The majority (70.29 %) of the respondents in the survey were male-headed households (Table 1).

Table1. Household headship characteristics of the Sample Respondents

Household head	Percentage of Respondents (n=138
Female Headed Household	70.29 % (97)
Male headed households	29.71 %(41)
Aykina Tsila (Highland AEZ)	32.68% (43)
Aykina Fane (Midland AEZ)	32.09%(46)
Aykina Gorpha (Lowland AEZ)	35.23 %(49)

Majority of the household heads who attended the most number of years in school were found in Tsila (four years) compared with one year for Aykina Fane. The most experienced farmers in terms of average number of years of farming within their localities were also in Aykina (approximately 30 years), compared with Tsila (Table 2). The average household sizes were six, and eight and six for Gorpa, Aykina and Tsila kebeles respectively.

Table 2. Means of different household characteristics sample respondents (n=138)

Household Characteristic (Mean)	Name of *kebele*			Standard Deviation
	Aykina Gorpha	*Aykina Fane*	*Aykina Tsila*	
Age of household head	45	47	43.72	44.25
Years spent in schooling	3	1	4	2.25
Farming experience	27	30	25	26.74
Family size	6	8	5	6.25
Annual total income	0.55	0.67	0.56	0.52

Smallholder Farmers' Perception and Knowledge of Climate Change and Variability

Households were asked about their perceptions of temperature volume, heat intensity and rainfall amount, distribution and patterns and extreme events changes trend in the last two to three decades. 88.73 % farmers perceived an "increase" in temperature volume, 2.75 % of respondents perceived a "decrease" in temperature volume, 5.74 % of respondents perceived "no change" in temperature volume, 2.78 % respondents reported they don't know about change volume. On the other hand, 87.64 % of the respondents felt an increase in heat intensity; 1.75 % of the respondents perceived a decrease in heat intensity; 19% of the respondents claimed no change in heat intensity; 1.85% of the respondents reported they don't know about temperature change (Table3).

Most of the interviewed farmers perceived precipitation changes, amount of rainfall and/or distribution, in the study area over the last 30 years. Substantial percentage of respondents (85.6 %) perceived the change in the amount of rainfall. Out of 85.6 % respondent who perceived the change in rainfall amount, 83.64 % of the respondents felt a decrease in the amount of rainfall, and the remaining 6.34 % respondents oppositely felt an increase in the amount of rainfall; on the contrary, 3.02 % of the respondents noticed no change in the amount of rainfall; 3% of the respondents did not give enough attention about the trend of the rainfall volume. The result also indicated that the majority of the respondents (89.6 %) noticed a change in the timing of rains, specifically, 90.68 % observed shorter rainy seasons, and 5.65% observed extended rainy seasons; 3.67% of the respondents observed no change in the rainy season.

Table 3. Households' Perceptions of Changes in Rainfall and Temperature over the Last 20 Years

Households' Perception (Counts of households (%) that....	Precipitation	Temperature	
	Rainfall Amount	Temperature Volume	Heat Intensity
Perceived an increase	1.25	88.73	87.64
Perceived a decrease	85.6	2.75	1.75
Perceived no change	5.2	5.74	8.76
Did not know	7.95	2.78	1.85
Total(n)	138	138	138

Temperature and rainfall are the two climatic variables that influence farming the most in the study area. In farming, the amount of rainfall is important and is an indicator of long term changes in the climate system. However, of more importance to farmers is the pattern of the rainfall. If the rain falls in the right amount and then it ceases for a long period before the next rain, the long dry spell can be devastating to farmers. The farmers were also asked about whether they perceive that climate is changing and if so, to mention the most important changes they perceived. The most important changes they noticed and ranked as first are summarized in Table 4

Table 4. Farmers' observation and perceptions about climate changes and variability

Most important climate elements change factors farmers' observed and recognized	Percentage of sample respondents(n=138)
Rains have become more erratic	58
Rainfall starts late and ends early	65
Extremes in temperatures	62.6
Long dry spells during the season	55
Rains don't come when they normally used to	72
Prolonged/extended winter season	5.4
Short winter season	2.7
Too much/heavy rains	1.3
Rainfall distribution within seasons now poor	1

Note: A multi response frame was used. Hence, total count is more than the number of respondents

Among the other important indicators, overwhelming majority of farmers' 72% replied that rains do not come when it normally used to; 65% replied that rainfalls late onset and early termination; and the 62.57% replied as extreme temperature, longer periods of drought and more floods were noticed largely. The study area has normally two rainy seasons (Bimodal rain season) in long past. The onset of the first rainy season was perceived by farmers to be later nowadays than before (Table 5). Conversely, the first season termination was also mentioned to be earlier. In the long past, the first rainy season onsets from early March and prolongs to Early May and the second rainy season onsets from late July and prolongs to early September. But now the farmers reported that heavy rains fell within one month, mostly at middle of April for the first rainy season and early August for the second rainy season and the distribution had become more unpredictable and erratic in both cases. The farmers noted that in the past, rainfall distribution over the season was even (normal) and they could manage to plan their agricultural activities properly and effectively, knowing when to expect significant dry and wet spells. The survey result also corroborates with key informant interview report. A farmer in his early 70s explained that:

"…in the long past when I was teenager , conducive and normal rains used to onset early in the month of March, but nowadays, the rainy season starts at the Mid of April and ceases early May, and this is now confusing farmers, rains are now very unpredictable. There were clear cut differences and consistency in trends and patterns in the seasons when we were young but nowadays there are a lot of disturbances, it gets cold when it is not supposed to and gets hot when it wants, rains are no conducive and good for agricultural activities. Seasons are very confusing to us nowadays…"

Farmers' perception in precipitation proves a significant variation across the three different agro-ecological zones (Table 5 and Table 6). The lowland farmers' are the one with the highest proportion of respondents who observed a decrease in rainfall amount and the least to perceive an increase in amount. This is probably because in the lowland zone water is already getting seriously scarce, and a little variation in the volume of rainfall could be recognized highly, for existing livelihoods are already on climatically stressed conditions.

Table 5: Farmers' observation rainfall amount change by agro-ecology

Agro-ecology	Farmers' observation on rainfall amount per day & season (%)				X^2
	Increased	No change	Decreased	I do not know	
Lowland	4.56	8.20	82.42	4.82	29.89*(df=9)
Midland	17.76	32.23	44.32	5.69	
Highland	22.60	27.95	39.96	9.49	

* Significant at 1% level

Table 6: Farmers' observation of rainfall pattern change by agro-ecology

Agro-ecology	Farmers' observation on rainfall pattern (%)			X^2
Agro-ecology	Changed	Not changed	I do not know	
Lowland	89.80	4.56	5.64	76.9*(df=14)
Midland	57.60	37.25	5.15	
Highland	43.65	52.80	3.55	

* Significant at 1% level

The variance analysis of farmers' observation and perception of heat intensity per day and number of hot days per year by agro-ecology revealed that there is no statistically significant variation in perception of temperature across the agro-ecological zones. This could imply that the change in temperature occurred in all agro-ecologies and it was experienced more or less equal by every farming community. The analysis of variance for perception of temperature change shows significant variation among the different educational levels.

Commonly practiced Climate-smart agricultural practices

Farmers' adopted various climates –smart agriculture (CSA) deliberately to protect their livelihood from severe consequences posed by changes and variability in the climate system. Also, others unintentional implemented climate–smart agricultural practices. So, those adopted climate-smart agriculture without recognizing and understanding the change and variability in climate could not sustainably implement the CSA's Practices, because it was not based on solid awareness and understating of the risk of climate change and its very purpose was not sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change and reducing and/or removing greenhouse gases emissions. The survey result proves that about 33.76% of adopted agroforestry, 25.62% soil and water management measures, 20.5% crop management and 20% used livestock management practices.

Table 7. Climate-smart agricultural practices adopted by Sample Respondents

Climate-smart agricultural practices	Percentage of Respondents Adopted
Agroforestry (Boundary trees and hedgerows, multipurpose trees)	33.76%
Soil and water management (Terraces and bunds, Contour planting	25.62%
Livestock management (Fodder crops, improved feeding strategies (e.g. cut &carry))	20%
Crop management (Crop rotations, Intercropping with legumes, biological weed & pest mgt	20.50%

There is also statistically significant variation of farmers' perception status and adoption of climate change-smart agricultural practices. Generally, as the survey result reveals 62.56 % of the sample respondents perceived and aware of changes and variability in climate where as 37.44% did not perceive the change and variability in the climate. From the perceived entire respondent only 53.75% adopted at least one climate change-smart agricultural practices whereas 46.25 did not adopted any climate change-smart agricultural practice. Also, from not perceived farmers' 21.65% adopted at least one climate change –smart agricultural practices and 78.35% not adopted any climate change-smart agricultural practice. So, though perception is not all cure solution for adoption of climate change-smart agricultural practices, it has a strong association with adoption of change-smart agricultural practices.

Table 7. Adoption of Climate change -smart agricultural practices by perception

Status of farmers' perception of changes and variability's in climate (%)	Adopted climate change-smart agricultural practices (%)	Not adopted climate change-smart agricultural practices (%)	X^2
Perceived *(62.56)=100*	53.75	46.25	78.6**(df=16)
Not perceived (37.44)=100	21.65	78.35	

* Significant at 1% level;

Determinants of farmers' Perception of climate change and variability

It is interesting to know which types of farmers are likely to recognize the climate change - an important issue to understand for practicing adaptation strategies. For this study, temperature increase and rainfall decrease are considered as the two measures of perceptions. To identify the correlates of farmers' perception of change in climate, the dependent variable is a binary variable that takes the value 1 if the head of household perceives that temperature is increasing or rainfall is decreasing from last twenty years and the value 0 otherwise. Farmers should perceive changes in the climate trend s to respond effectively through adaptation practices. It is through adaptation that they can minimize adverse effects of climate change in their agricultural production in particular and livelihoods in general. The sustainability of implementation of adaptation strategies also depend upon the right belief, perception, knowledge and commitment of the smallholder farmers' themselves. However, ability of farming households to perceive climate change is affected by diverse socio-economic, demographic, biophysical and institutional factors. Table10 below presents the logistic regression coefficient together with marginal effects after the dependent variable (perception) was regressed on a set of explanatory variables that have been discussed beforehand. Those factors had significant influence on farmers' perception to climate change in Geze Gofa Woreda. The others can be seen from the table. In this section the factors associated with the perception that climate is changing by sample respondents are investigated. The results displayed in Table 10 below showed the following.

The model outputs from regression indicated that most of the independent variables have significantly influenced the smallholder farmers' perception of climate change ad variability. Variables that positively and significantly influenced the perception of the farmers about the change in climate conditions over years include access to Training programs & campaign on climate change and environment conservation and sustainable utilization issues, knowledge of indigenous early warning information, access to timely weather forecasts and early warning information in local languages, increased frequency of contact with agricultural extension agents, educational level of household head and age of the household head. In this regard, increasing the exposure of a farmer to awareness meeting on climate change issues and natural disasters plays positive role in terms of improving farmer's perception of future changes. From this, it is apparent that investment on improvement of the ways in which early warning information dissimilates and improvement in the education level of household head would yield a better result in terms of improving the understanding of the prevailing climate change.

Further, the econometric model also revealed that among household characteristics, sex, level of education, and farming experience positively and significant influenced perception to climate change. Farming household heads with education and more farming experience are more likely to perceive changes in climate than those with less farming experience and less education. The point that education and farming experience have significant association with perception implies the capability of experienced and educated farmers to better access information about climate change compared to those with less experience and education. Studies show that with more experience and education, farmers develop knowledge and skill that may help them sense risks better (Maddison, 2007; Deressa etal. 2011).

On the other hand, the model output has shown that variables like distance from the market was negatively related to the perception of climate change though not found as such significant. This is due the fact that the more a farmer is distant from output market and input market, the less likely he or she can have more contacts for information sharing. Market places are usually the place where rural household exchange information regarding all matters of the agricultural activities as well as socio-economic issues. Market places in the study location are very few, where some of the farmers were required to travel more than half a day to reach market places. From the above Table 5, it is apparent that a unit increase in the distance of farmers from a market will lead to an increase in probability of not perceiving by significant level. Similarly, the male headed households have better level of perception to climate change as compared to female headed households, this is may be because of the network of a family in accessing information which indicates a differential access of gender to climate change information issues. This result is in line with the argument that male-headed households are often considered to be more likely to get information about new technologies, climate and take risky businesses than female-headed households (Asefa and Berhanu, 2008).

Table 10: Logistic regression result for perception of soil conservation practices

Dependent variable: Perception	*Coefficient*	*Std. Error*
Independent Variables		
Gender of household head	1.24**	0.625
Age of household head	-0.321*	0.2565
Farm size	0.255**	0.125
Farm experience	1.57**	0.650
Access to credit service	0.32*	0.202
Distance from market	-0.321*	0.325
Family size	1.34**	0.721
Access and Ownership of audiovisual Medias	0.24	0.570
Membership in CBOs and other social groups	0.259***	0.089
Extension workers visit/contact	0.257*	0.096
Livestock ownership	0.23	0.1652
Previous exposure to climate extreme events	0.268***	0.098
Agro-ecology: Lowland	1.327***	0.205
Midland	0.054	0.087
Highland	0.011	0.033
Involving in off-farm and non- farming	0.77	0.351
Access to irrigation and water harvesting schemes	1.43**	0.680
Access to Training programs & campaign on CC	0.37**	0.227
Access to formal weather forecasting's	1.037*	0.602
Access to indigenous early warning system	0.111*	0.0069
Annual household income	0.90*	0.5532

Model Chi-square 102.480
Log likelihood function 96.234
Nagelkerke (R2) 0.792
Number of observation: 138

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

Conclusion and policy Implication

The study explores the detail empirical picture of farmers' perception of climate change in Geze Gofa Woreda. The smallholder farmers' in Geze Gofa *Woreda* have exhibited a higher level of perception of climate change and variability. According to the findings of the study, large number of farmers has good perception level about the changing temperature volume and heat intensity, rainfall amount, distribution, onset and offset increased frequency and intensity of weather and climatic extreme events and others. The high level of perception was a result of access to awareness raising campaign by some NGOs, educated family members and extension workers, access to indigenous early warning information, farmer's location in terms of agro-ecology, closeness to market, educational level, and age of household heads. They feel a major shift in agro-ecological conditions i.e., the area is becoming hotter and drier. However, the way farmers perceived the changes in climate significantly varies across agro-ecologies, farming experience, gender, and educational level. Although overwhelming majority of farmers appears to be well aware of climate change, few seem to actively undertake adaptation measures to counteract climate change. Indeed, almost 42 % did not undertake any remedial actions. This can imply perception is a necessary ingredient for adoption of adaptation strategies, but not the only panacea for the problem.

With properly specific evidence-based policy, smallholder farmers can adjust to climate change and improve their crop production. To do this, climate change policies need to factor in farmers' understanding of the risks they face and potential adaptations to climate change. The perception that climate change is also caused by traditional ancestral curses implies that scientists and development experts should consider the cultural and traditional beliefs of farmers when designing adaptation practices. As such, a bottom-up approach must be used to ensure that farmers' beliefs and understanding are a crucial part of the design and dissemination of adaptation practices**.** Farmers' access to timely weather information also needs to be prioritized to help farmers in their production decision-making processes (e.g., selection of adaptation options). The Ethiopian meteorological agency and agricultural staff need to be properly trained and resourced to collect, collate, and disseminate accurate weather information and early warnings timely and widely.

Also, the government should boost the capacity of scientists and agricultural staff to develop and promote appropriate and effective technologies to help farmers adapt to climate change. In addition, the prevailing high cost of farm inputs and lack of credit facilities and subsidies require the government to ensure that agricultural loans with flexible terms are made available to farmers to boost their capacity to adapt to the changing climate. Results find that farmers of Geze Gofa especially those with assets, access to credit, extension services and, greater participation in groups and more exposed to climate change shocks; are already perceived that climate is changing. Participation in social groups is particularly important in enhancing their perceptions of climate change which should be encouraged by government with appropriate policy intake. Government policies should be initiated to improve household access to extension services and access to credit and information, which would improve and diversify farmers' knowledge of climate change and perception and thereby to improve their adaptation strategies. Improving opportunities for households to generate off-farm income could provide a further strategy in response to negative shocks. The understanding of how farmers perceive climate risk is valuable to other stakeholders such as extension service, providers and climate information providers as it can assist in tailor-making their services to suit the farmers' needs and support them to better cope and adapt with climate variability. The results in the study indicate that farmers have a biased estimation of poor seasons, probably because human behavior attaches higher significance to negative events, and this could have a significant role in farm decision-making and farm investments. Farmers' perceptions of climate variability are important as it determines the process of how to provide relevant meteorological services. The study reveals that farmers may also be more concerned about within season rainfall variability, than pan-seasonal variation which seems to be the major factor constraining semiarid agriculture, a finding also documented by

Enhanced communication of climate-related information could be an option to assist in adaptation strategies and timely decision-making by farmers. The use of the seasonal climate forecasts could help farmers and stakeholders plan forward and make informed, sustainable as well as economically meaningful *ex ante* agricultural management decisions. Government of Ethiopia could play an important role in creating a favorable policy environment that promotes dissemination of seasonal climate forecast information and improved extension service provision so that agricultural management practices are enhanced for improved productivity. Since within season rainfall is also one of the major problems, and the amount of rainfall cannot be influenced, then technologies that enhance water use efficiency could also be one of the major areas of research and development that should be integrated into the semi-arid maize farmers' existing strategies to adapt to climate variability and ultimately change Climate change communication provides an avenue through which perceptions of resource users can be integrated in climate change adaptation projects. This would facilitate exchange of climate change information between smallholder farmers on one hand and donors and conservation agriculture project implementers on the other. It would also provide additional climatic information that would enable farmers relate to conservation agriculture as an adaptation strategy

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