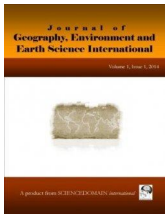

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Smallholder Farmers' Perception and Responses to Climate Change and Variability in West *Shewa*, Oromia, Ethiopia

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

Agriculture, on which all the human being depends for their food is under serious threat from the impact of climate change. *Primary aim of this study was to assess the smallholder farmers' perception to climate change and variability, and to investigate* the measure they employed in the response to their perceived change and to analyse factors that influence their ability to adapt in Adea Berga district of west shewa zone, Oromiya regional state of Ethiopia. Study was conducted by including 241 smallholders from four local kebeles'[1]. A two steps process of Heckman model was used to analyse adaptation to climate change, which initially requires farmer's perception to climate change and then responding to perceived changes through adapting one of appropriate strategies among various options in their hand. The analysis result of selection model shows that age (0.000), access to extension service (0=0.022), access to climate information (0=0.005), soil fertility (0.016) and agro-ecology (0.046) were significantly affected the perception of smallholder farmers to climate

[1] *Kebele is the lower administrative unite in Ethiopia government structural hierarchy*

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change and variability. Similarly, farmers' adaptation strategies to the response of perceived change in climate was affected significantly by sex (p=0.037), age (0.010), access to extension service (0.011), access to climate information (0.019), wealth status (0.008), involvement in nonfarm income (0.038), soil fertility (0.001), access to credit service (0.000), increase in temperature (0.025), no change in temperature (0.002), decrease in temperature (0.003), change in timing of rainfall (0.000) and experience in the occurrence of hazards (0.014). Policy implications of this study are call for providing unreserved intervention of the policy makers including the local planner to due attention on reducing the factors that significantly influenced the adaptation decision of farmers and building on the adaptive capacity of the smallholder farmers in Adea Berga district.

Keywords: Climate change; variability; perception; response; factors.

1. INTRODUCTION

Agriculture on which all the human being depends for their food is under serious threat from the impact of climate change. This is mainly because climate change severely affects the key climatic variables (i.e., rainfall and temperature) that affect agricultural production and food security across the globe [1]. Besides, the consequent impact of climate change that manifested in the recurrent drought, floods, and famine that have threatened millions of people and livestock in recent decades is also the other worst side of climate change [2]. As a result, a community which mainly depends on agriculture for their living, developing countries in general and smallholder farmers in particular are being especially hard hit by these changes [3].

Globally smallholder farmers are known as they are disproportionately vulnerable to the impacts of climate change as a result of their poverty level, marginalisation in the range from the area where they located to access to whole important input and reliance on natural resources for their livelihood [4]. According to [5] these smallholder farmers inhabit some of the most at risk landscapes, including hillsides, and floodplains. As a result climate change multiplies the threats facing smallholders, endangering the natural assets they depend on and accelerating environmental degradation. As result, smallholder farmers will suffer greater impacts from the emerging climate change related problems, such as increasing weather variability, extreme temperatures, shorter growing seasons, high solar radiation, greater moisture stress and new pests and diseases [6].

Moreover, smallholder farms that predominantly concentrated in Asia and Africa, accounts for large shares of the total agricultural area and output [7]. And they also had known as home to some 2 billion people, including half the world's undernourished people and the majority of people living in absolute poverty [8]. However, though they are the home and feed billions of the world poor and also contributes highest for the economic development of the poor developing countries they has not been get enough attention from the government in the way that can show change in their life. These may be done through in various ways such as making accessible the rural finance that can support them to buy new technologies, building road, health center, water availability: for drinking and to their livestock; access for input: in price, location, availability when they want; market: to buy input and sell their output; and education that can play a great role in supporting their indigenous perception to climate change through the scientific manner. Just as other African and Asian countries agriculture has been the main stay of the country Ethiopia and is also dominated by smallholder farming. It engages about 11.7 million smallholder households of the country and account for about 95% of agricultural GDP and 85% of employment [9].

Besides, the sector is dominated by subsistence, low input-low output, rain-fed farming system with very limited areas of irrigation [10]. Such great dependence of country on smallholder farmers by this much is mainly suggested as the core reason for the vulnerability of the country to the impact of climate change. The impact may further be exacerbated by poor extension service, institutional capacity, high population growth, continuing reduction in soil fertility due to soil erosion caused by deforestation, insufficient climate-related information and poverty which significantly reduces the capacity to mitigate, adapt with the various effects of climate change [11].

Though farmers of the country try to adapt with the effects of climate change but their attempt is seriously impacted by limited adaptive capacity,

few alternative sources of income, lack of expertise, and lack of appropriate public policies and financing [2]. As part of the country, *Adea Berga* district is found in west *Shewa* zone of *Oromia* regional state is, therefore, us not an exception to be hit hard by the effects of climate change. The district is where smallholder farmers solely relay on subsistence rain fed agriculture and strives to live with the already changed system in their local climate. Just as other smallholder farmers in the country, farmers of the specific local community are also faced changes in rainfall levels and distribution, rising temperatures and variations in soil carbon utilisation by crops due to climate change. The situations are commonly expected to negatively influence the growing conditions and the potential yields of many crops in Sab Saharan Afirica [12].

Accordingly, the purpose of this study was to assess the smallholder farmers' perceptions and adaptation practice to the effect of climate change. Hence, the paper aimed to analyse the measures taken by farmers in adapting climate change and factors that determined farmers from adapting to the impacts of climate change. Thus, it was important to explicitly understand their perception and strategies they implied to live with the changed climate system. This is because adaptation to climate change is a two-step process; the first step requires the farmers to perceive a change in climate and the second step requires them to act through adaptation [13].

However, much of the documented information on the impact of climate change and its associated variability is at the country level. There is an increasing need for a more organised body of information and perception at local levels on the location-specific impacts of climate change and variability on the agricultural-based livelihood systems that mainly owned by smallholder rain fed agriculture as well as on best practices and options to increase awareness and preparedness for adaptation to climate change [6]. With having this inherent consideration the primary aim of this study was (1) to assess the smallholder farmers' perception to climate change and variability in the study area; (2) in order to identify locally practiced adaptation strategies by farmers in the response to perceived change in climate of the area; and (3) to analyse determinants of farmers' choices of adaptation strategies to climate change and variability in *Ada'a Berga* district of west *shewa* zone.

2. METHODOLOGY OF THE STUDY

2.1 Description of the Study Sites

A study was conducted in *Adea Berga* district of West *Shewa* zone in *Oromia* region, Ethiopia. The district is about 107km north east of zonal town *Ambo* and 60km west of Addis Ababa. *Adea Berga* is bordered in the south by *Walmara,* in the southwest by *Ejerie,* in the west by *Meta Robi,* and in the north and east by *Muger* River, which separates it from the *Semien Shewa* zone. The study was conducted in four *Kebels: Gatira Nebe, Odomojo, Sembaro Sego* and *Dire Medale Kebele* (Fig. 1). Geographically, it lies between coordinates of 9°12" to 9°37" N and 38° 17" to 38° 36" E [14].

2.2 Sampling Procedure and Data Collection

A multi-stage sampling procedure was applied to select respondents for the study. *Adea Berga* district was purposively sampled because of the high vulnerability of the area for climate variability and its impact. First kebele's within the district were stratified in to three agro-ecologies i.e., highland, midland and lowland. Of the three strata the study was conducted by considering two agro-ecologies, midland and lowland. Because farmers of the district particularly living in the two agro-ecologies were ranked as relatively more vulnerable to climate change and variability according to the vulnerability profiling reports of zonal level disaster prevention and preparedness office [15]. Following these four *kebeles* were selected randomly from two agro-ecologies, *Gatira Nebe and Odomojo* from midland and *Sembaro Sego* and *Dire Medale* from the lowland. Respondents from each of the sampled kebele were drawn by chance using the rule of proportion to their total population. In all, the analysis in this paper is based on data from a sample of 241 farmers drawn from four communities in *Adea Berga* district.

Primary data used for this study was obtained through survey questionnaire administered to respondents at the grass root levels. The questionnaire was sought for information including demographic and socio-economic conditions, institutional factors, perception on both long and short period changes in temperature and precipitation, major climate change and variability related impacts and the local adaptation strategies that commonly followed by farmers. On the other hand focused

group discussion (FGD) and key informant interview were employed to triangulate quantitative data collected through survey. The FGD that made with elderly farmers mainly focused on more detail and specific issues related to climate change and variability. Key informant interviews were conducted to get qualitative data in addition to FGD was primarily focused on trends of climate variability and induced impact in their localities. In addition to primary data secondary data essential to substantiate this study was also collected from district and zonal level government office agriculture and disaster risk prevention and preparedness.

2.3 Methods of Data Analysis

Analysis was computed using both descriptive and inferential statistics. Quantitative socio-economic data collected through structured questionnaire were analysed using descriptive statistics. Descriptive analysis such as frequencies and cross-tabulations was used to determine a simple number of occurrence of a variable or relationship among variables through using the Statistical Package for Social Sciences (SPSS) v.20.0. Besides, an inference also made by econometric model, Heckman's probit selection model by analysing factors that influences both the perception of smallholder farmers and the response strategies to their perceived change in the climate of the area by employing STATA v.12 software.

2.3.1 Econometric model

Adaptation to climate change is a two-stage process involving perception and adaptation stages. The first stage is whether the respondent perceived there was a change in climate or not, and the second stage is whether the respondent adapted to the climate change, conditional to the fact that he or she has perceived there was a climate change in the first stage. Because the second stage of adaptation is a sub-sample of the first stage, it is likely that the second stage sub-sample is non-random and different from those who did not perceive climate change creating a sample selection bias. Therefore, this study was used Heckman's well-known maximum likelihood two-step procedure to correct this selectivity bias [16]. The Heckman's two-step procedure has advantages over the other models such as the multinomial logit and multinomial probit models as these models are not suitable for analysing the two-step procedure of adaptation. Heckman's sample selection model assumes that there exists an underlying relationship which consists of:

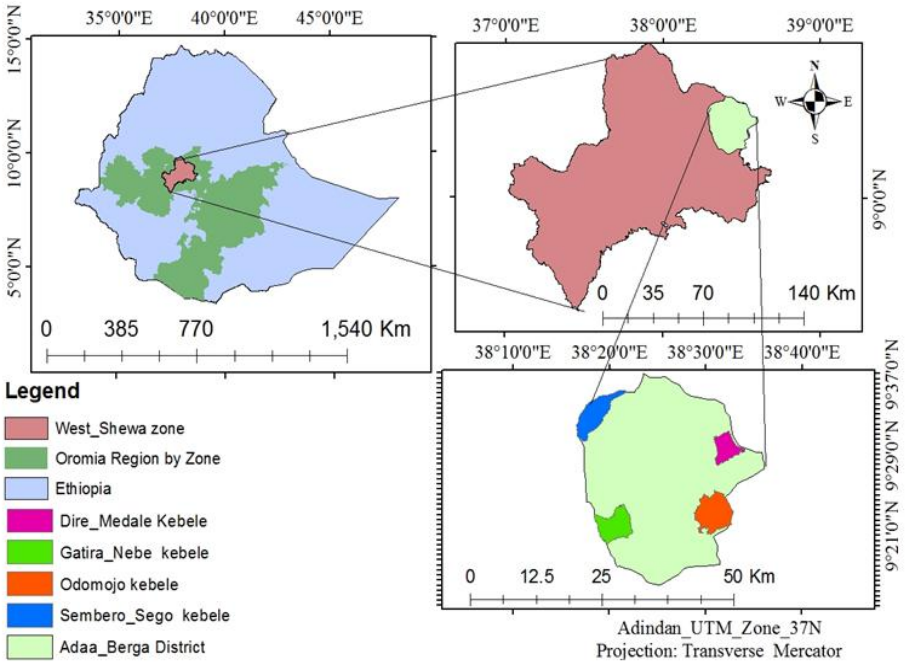

Fig. 1. Map of the study area

The latent equation given by:

$$yj^2 = x_{j\beta+}u_1j \quad (3)$$

Such that we observe only the binary outcome given by the probit model as:

$$y_{jprobit} = (y_j^* > 0) \quad (2)$$

The dependent variable is observed only if the observation *j* is observed in the selection equation:

$$y_{jselect} = (z_j^{\delta} = u_{2j} > 0) \quad (1)$$

$U_1 \sim N(0, 1)$
$U_2 \sim N(0, 1)$
$Corr(U_1, U_2) = p$

Where *x* is a *k*- vector of explanatory variables which include different factors hypothesised to affect adaptation and *z* is an *m* vector of explanatory variables which include different factors hypothesised to affect perception; U_1 and U_2 are error terms. The first stage of the Heckman's sample selection model is the perceptions of changes in climate and this is the selection model (Equation 3). The second stage, which is the outcome model (Equation 2), is whether the farmer adapted to climate change, conditional on the first stage that she or he perceived a change in climate.

When, $p \neq 0$, the standard probit techniques applied to equation (1) yield biased results. Thus, the Heckman probit provides consistent, asymptotically efficient estimates for all parameters in such models [17]. Hence, the Heckman probit selection model is employed to analyse the perception and adaptation to climate change in *Ada'a Berga* district.

3. RESULTS AND DISCUSSION

3.1 Demographic and Socio-Economic Characteristics of the Respondents

The basic characteristics of smallholder farmers' in terms of natural resource, human resources, existing institution and infrastructural base on which the respondents depend was not that much different across the study agro-ecologies. However, understanding how these conditions including demographic and socio-economic characteristics, interact with one another is among important parts of this analysis to know how it influences farmers' perception and response ability toward climate change and variability. Accordingly, of 100% (n=241) of respondent considered in this study, about 86.7% were male and the rest 13.3% were female headed households (Table 1). Regards to age majority, 86.7% of respondents were included from the age group between 30 to 60 years of old. This indicates that the age distribution of farmers in the area was concentrated to middle age group. Mean number of family size was 6.13 with minimum and maximum of 2 and 12 persons, respectively. Similarly, 68.3, 17.3 and 14.4% of informants were included from illiterate, who able to read and write, and completed primary levels of school, respectively. Regards to farming experience majority of farmers considered were from middle level of farming experience, 68.3%.

Of the surveyed, high numbers of farmers were considered from medium level of wealth categories (i.e., poor, medium and better-off wealth categories), 71.7% according to their own local categorisation of the households under poor, medium and better-off farmers (Table 1). This shows that majority of farmers in study area were under the wealth category of medium level. On the other hand 60 percent of farmers have been practicing farming mainly for household consumption rather than for making money. This may be due to 70% of farming of their agricultural practice was solely depends on rain fed agriculture rather than focusing on alternative means of irrigation. This was also considered as the main reason for the farmers to lead subsistence type of farming for any cost of need of their family including annual health and education expenditure.

Concerning, extension service that supports farmers to increase their productivity was not encouraging because majority 58.3% of respondents mentioned as they were visited once in the year and only 40% of informants reported as they were frequently visited within the given cropping season (Table 1). This is one of key institutional support in order to early inform farmers about the near or seasonal situation of climate, create awareness about newly fabricated agricultural inputs and the technic how to use it.

Around 82.3% of interviewed were informed about the existence of climate change at large. Accordingly, 90.1% of informants noted they

were perceived increase in temperature of the area while 35.5, 26.2, 19.1 and 19.1% of respondents reported as they were noted change in timing of raining, decrease in the amount of total rain fall, and increase in the frequent occurrence of drought and amount of rainfall, respectively (Table 1). This implies that high numbers of farmers in the area had perception about current climate reality following by the impact of frequent occurrence of hazards and its distractive damage observed on their farming.

Regards to credit service, about 68.3% of respondents were reported have access to use the service when they want it and the remaining 31.7% of informants indicated they had no access to credit service (Table 1). Lack of access to credit service implies that though there is office in the district and facilitators in their *kebele* the complex requirement such as collateral issue is one of limiting factors of their access. Even, those who said they have access to credit service is not to mean all of they used the service and they don't face the same challenge rather just to mean the existence of the institution in their community and have access at the time they want it. On the other hand farmers have no access to rural finance mean they have no ability to own new technologies particularly those who are relatively poor in terms of lack of finance and assets that can easily be changed to money.

From the interviewed, based on the analysis result (Table 1) majority 58.3% of the respondents had not experienced on the alternative way of income generation in terms of none farm income activities. Concerning their practice to off-farm activities, 82.3% of farmers confirmed as they had no experience of involvement on that type of income diversification means. Since the livelihood of farming community was mainly depends on rain fed agriculture, soil fertility is also the other major factors of productivity but in the study area high numbers, 91.7% of respondents reported the land on which they do farming is less fertile and only 8.3% of farmers noted do farming on fertile land. According to their explanations fertile means, the land they owned is relatively productive without applying fertilisers. In addition, farmers ensure that infertile land is among major limiting factors that challenge farmers to adapt the double burden of both the short and long period changes in climate.

3.2 Smallholder Farmers Perception on Climate Change and Variability

Farmers' perception or perception on climate change and variability is a necessary prerequisite to take any response action. This is because, farmers decide to adopt among different options of area specific strategies if they perceive the existence of climate change [18]. Given an appropriate response to climate change requires two step processes. First, perceive the existence of climate change and its associated risks. Second, responding to perceived changes in climate to minimise their adverse impacts on their living. As result, accuracy of perception on whether there was long or short period of change in climate or not is a necessary pre-condition for a meaningful response, which eventually depends on perception and experience. Because, among the other factors, having accurate perception about the risks associated with climate change is essential for motivating farmers in their decision to adapt [19].

In order to understand farmers' perception towards climate change in *Adea Berga* district, farmers were asked to indicate what they had noted regarding long term changes in temperature and precipitation. As the understanding on global climate and its change is pre requisite to take appropriate initiatives to combat climate change [20]. Accordingly, the results of this analysis in Table 2 indicate that 82.3% of the farmers in the district had noted changes in climate while 17.7% had not. Whereas, 90.1% of the interviewed confirmed as they observed increase in temperature of the area, about 35.5% reported change in timing of rain. On the other hand nobody was reported to have perceived a decrease in temperature of the area and no change in the pattern of precipitation of the area. But 5.7% of respondents reported they not know whether there was change in temperature or not and the rest, 4.3% of farmers reported there was no change at all in the temperature of the area. Regards to the patterns of precipitation, 26.2% of respondents noted that they had recognised decrease in the amounts of rainfall. The same numbers, 19.1% of farmers reported they observed increase in the amount of rainfall and frequent occurrence of drought in the area over time. This is also in line with various studies conducted in developing countries. Because, several research made in other developing countries indicate that most farmers perceive temperatures to have become warmer and rainfall reduced over the past decade or two [21,22,23,24].

Table 1. Demographic and socio-economic characteristics of the respondents

Variables and variable measurement	Description/response	Frequency	Percent (%)	Expected sign
Gender of the head of the household: dummy (1 = male; 0 = otherwise)	Female	32	13.3	±
	Male	209	86.7	
Age of the head: Categorised	Below 30 years	237	1.7	±
	Between 30 & 60 years	209	86.7	
	Above 60 years	28	11.7	
Household size: number of family members of a household: in number	More number of dependent family group	357	81.7	±
	No dependent family group	116	18.3	
Education level of the head of the household: Categorised	Illiterate	80	68.3	+
	Able to read & write	44	14.4	
	Primary level	117	17.3	
Farming experience: Categorised	Short: less than 10 years	8	3.3	+
	Medium: between 10 & 30 yrs	149	61.7	
	Long: above 30 yrs	84	35.0	
Wealth status of the households: Categorised	Poor	44	18.3	±
	Medium	173	71.7	
	Better-off	24	10.0	
Reason of farming: Categorised	For household consumption	145	60	±
	For both household & market	96	40	
Types of agriculture: Categorised	Rain fed	169	70	±
	Irrigation	72	30	
Access to extension services: Categorised	No access (once in year)	4	1.7	+
	Rare: once in the year	141	58.3	
	Frequently visited	96	40.0	
Access to climate information: dummy (1 = access; 0 = otherwise)	Yes	233	96.7	±
	No	8	3.3	
Temperature: farmers who perceives affected due to observed changes in temperature: Categorised	Increase	227	90.1	$\pm$
	Decrease	0	0.0	
	No change	6	4.3	
	I didn't considered	8	5.7	
Precipitation: farmers perceives affected due to observed changes in precipitation: Categorised	Increase in PPT	46	19.1	$\pm$
	Decrease in PPT	63	26.2	
	Change in timing	86	35.5	
	Increase in frequency of drought	46	19.1	
Access to credit: Dummy (1=access; 0=otherwise).	Yes	165	68.3	+
	No	76	31.7	
Involvement in non-farm: Dummy (1=access; 0=otherwise)	Yes	100	41.7	+
	No	141	58.3	
Involvement in off-farm income: Dummy (1=access; 0 = otherwise)	Yes	76	17.7	+
	No	165	82.3	
Fertility of soil owned by HH: Categorised	Infertile	8	3.3	±
	Less fertile	221	91.7	
	Fertile	20	8.3	
Total		241	100	

Source: Survey result of 2017

A cross tabulation made between age of the household head and perception on climate change and variability indicates that existence of significant difference among age group at p<0.01 level. Accordingly, the majority, 85% of farmers aged above 60 years were recognised change in climate of the area were compared to 81.8 and 50.0% of respondents included from the age group of between 30 to 60 years and below 30 years of respondents, respectively. They ensure this because 100%, 90% and 81.8% of farmers from age group above 60, between 30 and 60, and below 30 years, respectively were perceived increase in temperature of the area and none of the respondents were reported as they considered decrease in temperature of the area. In addition to this, 54.5% of respondents from age group above 60 years were noted that they had recognised change in the timing of rain fall compared to 50 and 32.5% of respondents included from the age group between 30 and 60, and below 30 years, respectively. Likewise, almost similar number, about 100% of farmers considered from different age categories were experienced the climate induced hazards in their area, though the magnitude and intensity of its impact was different from time to time with type and nature of climate induced shocks. Firstly, it is apparent that more experienced farmers are more likely take up an adaptation measure [20].

Concerning educational level (i.e., completed primary school, who able to read and write and illiterate) of farmers' perception to climate change and variability, there was no significant difference in perceiving the presence of climate change in the area (Table 2). This implies that farmers who were illiterate mean not to mean they were not able to understand the change in climate and variability in their locality. Rather it shows that change in climate and its consequent impact on the living of the residents is very common and clear to observe. People who live and work close to agriculture do experience and understand climate change since climate has a profound effect on production [25]. For instance, 98.3% of respondents from illiterate and the same number of 100% of respondents from who able to read and write and completed primary school reported they experienced the different types of climate induced hazards in their community i.e., drought, damaging flood and its resultant impact in different form like loss of livestock, landslide, and on human health. In a number of African countries large numbers of agriculturalists already perceive that the climate has become hotter and the rains less predictable and shorter in duration [26].

Regarding to farming experience, showed the existence of strongly significant difference in perceiving climate change in the area at *p<0.000* level but variability in temperature and precipitation were not significant. This is in consistence with [27], indicate that most farmers with short farming experience (< 10 years) observed no change in temperature where as farmers with more experience (> 10 years) perceived an increase in temperature. In view of that, majority (91.4%) of farmers with long periods of farming experience confirmed their observation of long period change in climate of their locality compared to 85.7% and 40.0% of farmers from medium and short period of experience in farming respectively. In the respect of variability in temperature, about 92.3%, 91.4% and 73.3% of informants from long, medium and short period of farming experience stated increase in temperature of the area. But no informants indicated decrease in temperature of the area.

The analysis of farmers' perceptions of climate change indicates that most of the farmers in this study are aware of the fact that temperature is increasing and the level of precipitation is declining (Table 2).

On the other hand, about 31.4% of respondents confirmed decrease in the amount of rain fall compared to 26.7% and 24.2% of farmers from short and medium period experience of farming respectively. Similarly, none of farmers reported as they did not recognised change in precipitation of their community. However, farmers included from different farming experience considered the variability of temperature and precipitation at varying level but the impact of this variability in twine factors of climate was not differently reported across agro-ecology. As result, the same number of 100% of respondents from short and medium period of farming experience in comparison to 97.1% of farmers from long period of farming experience confirmed their experience of climate induced hazards in the area without showing significant difference among farmers include from varying farming experience. This inferred the existence of serious challenge for human life due to frequent occurrence of climate induced hazards caused by climate change and variability i.e., drought, animal disease, flood, soil erosion, landslide (due to indirect effects of damaging

flood) were common in the localities. Similarly, studies conducted by [27] in the upper catchment of Blue Nile reported losses in their agricultural production due to erratic rain, increased temperature, perils of flood and drought, and scarcity of water.

3.3 Farmers Response to Climate Change

During the surveyed period, farmers of the study area were asked whether they employed any type of measure in the response to their perceived change in climate. The reason for this question was that farmers are expected to adapt effectively to climate change once they relatively perceived the state of current climate and possible future trends [25]. Consequently, about 100% of respondents reported they employed one of the strategies mentioned under Table 3 though their average adoption of strategies was low to 79% due to variation in their biophysical and socio-economic characteristics. Farmer's decision to adapt depends on the context of their own environment, and differences also exist between perceived and real environments [28].

Accordingly, analysis result reveals that changing crop varieties from local to improve seed (93%), diversifying crop types (70%), making an adjustment in crop management (77%), changing in practice of livestock management (71%), Shifting in planting or cropping dates (99.3%), moving to a different site (53%), implementing soil and water conservation techniques (48.3%), moving to distant area in search of temporary work (51.7%), diversifying from farming to non-farming practice (58.3%), changing quantity of land under cultivation (58%) and off-farming activity (53.3%) and using of chemicals i.e., fertilisers, insecticides, herbicides…etc. (78.3%) are among the major strategies farmers employed to live with the changed and continually changing system of climate in their locality.

3.4 Factors Influencing Farmers' Response to Climate Change and Variability

Gender of the household head: is significantly, at $p<0.01$ levels affected the decision of farmers to take various measures in the response to perceived change in climate by 35.36% (Table 4). This implied that being female headed household didn't limited them from perceiving the observable change in climate of the area but having their low capacity to adapt showed significant difference in taking action to the perceived change in climate of the area. This agreed with the work of [29], argues that male-headed households adapt more readily to climate change in comparison to female headed households. This also because male headed households are more likely to get information about new technologies and undertake risky businesses than female-headed households, like agriculture, is one of climate sensitive sector of business [30].

Age of the household head: existence of difference in age of the household head revealed positive and significant difference both in perceiving the change in climate and taking an appropriate measure to the perceived change. The result of study was in line with [31] they noted as household which headed by aged farmers is positively responded to adaptation decision of climate change, since it represents experience of the household head.

Access to extension service: having access to frequent visit by extension worker within year in comparison to farmers who visited rarely through extension service increased the probability of perceiving climate change by 34.94% at $p<0.01$ level. Hence, perceiving the change in climate to this extent was increased the likelihood of farmers adaptation by 18.77% at $p<0.01$ level of probability (Table 4). In convergence to this, [32] argue that farmers who have access to extension services are more likely to be aware of changing climatic conditions and to have perception of the various management practices that they can use to adapt to changes in climatic conditions. Thus, better access to extension services has a strong positive influence on the probability of choosing in adaptation measures and thereby increases the chance of adaptation to climate change by farmers [33,34].

Access to climate information: having access to climate information, about the variability in the temperature and precipitation was enhanced the probability of perceiving the change in climate by 36.09% at $p<0.01$ level (Table 4). As hypothesised, farmers who have relative know-how about the climatic condition of their specific area where adopted from different options of adaptation strategies. Consequently, due to having knowhow to both long and short period change in major climatic factors, temperature and precipitation the likelihood of farmers' decision to adapt was raised by 43.82%.

Similarly, [31] found having information on temperature and rainfall has a significant and positive impact on the likelihood of using different adaptation option to climate change. Because, lack of information to climate variability was reported as the most important factor of adaptation by farmers in east Hararghe, Ethiopia to climate changes [35].

Wealth status of the household: Variation in wealth status of the households mostly assumed influence the decision of farmers to adapt because of having varying capacity to respond. In view of these, farmers who were relatively better-off were by 30.96% decided to adapt climate change and variability at $p<0.01$ level (Table 4). The result is in agreement with previous findings that showed that wealthier farmers are more likely to use adaptation practices in response to climate change than poor farmers [36].

Involvement in non-farm income source: In fact, with the current climate reality, farmers who have opportunity to generate additional income to his livelihood have relatively better adaptive capacity in comparison to who have no similar access for. The result of this study revealed that the households who had one more chance to get income from non-farm income source in addition to farm income was increased the probability of adapting by 53.64% with a significant difference at $p<0.05$ level (Table 4). In contrast to this, research conducted by [37], states that involvement in nonfarm income has a negative relationship with adaptation to climate change. The finder explains as the farmers' income increases from nonfarm activities they devote less time for farming therefore it negatively affects the farmers 'decision to climate change adaptation. In line to present study [31] argued that having chance for nonfarm income significantly increases the likelihood of planting trees and using irrigation as adaptation options.

Access to credit service: having access to rural financial service in the community is considered as an important tool to increase the financial capital of farmers to buy any new technology which is appropriate to their farming. As hypothesised, access to credit service to farmers took the expected sign and its coefficient was significant at less than 1% level of probability (Table 4). Consequently, increase in the access to get credit in the surveyed communities raised the likelihood of adapting to climate change and variability by 49.51%. In accordance to this study, [38], states that having access to agricultural credit will be the strong probability for using adaptation strategies to climate change and then will have positive and significant impact on the livelihood of farmer.

Increase in temperature: Perceiving increase in temperature of their locality and its consequent effect on the livelihood increased the probability of taking adaptation measure by 49.45%. In contrast, perceiving there was no change and decrease in temperature of the area reduced the probability of adapting to both long and relatively short period of variation in climate by 80.15% and 138.25% at $p<0.01$ level, respectively (Table 4). Similarly, study by [29] also indicates that households who perceived existence in change of temperature of their area more likely to adapt to climate change through adoption of different practices. The reason is that unusual increase in temperature of the area is damaging to agriculture so understanding this situation increases farmer's response through adopting different strategies of adaptation [39].

Change in timing of rainfall: rainfall is one of major factors of production in agricultural sector. The importance of rainfall particularly to rain-fed agriculture is very worth interesting. But change in timing of rainfall is scientifically believed as very damaging to the productivity of agriculture which solely relies on seasonal rain fall. As hypothesised, perceiving the observed change in the timing of rainfall in the area were positively raised the likelihood of adapting to climate change and variability by 89.00% at 1% level of probability (Table 4).

Experience in the occurrence of hazards: consideration of farmers to frequent occurrence to climate induced hazards in the area was positively associated with farmers' perception but not significant. Though their observation was not significant but the frequent occurrence of climate change induced hazards was significantly affected the decision of farmers with hypothesised sign at $p<0.01$ level of probability. With regards to this, farmers who observed the occurrence of various hazards in the communities were more probability to adapt climate change by 50.58% (Table 4).

Table 2. Farmers' perception to changes parameters by sex, age, education, farming experience and wealth status

Farmers' perception	Perception by sex (By %)		Perception by age (By %)			Perception by education (By %)			Perception by farming experience (By %)			Perception by wealth status (By %)			Total (n= 241; by %)
	Female	Male	0-30 years	30-60 years	60+ years	Illiterate	Able to read & write	Primary level	Short: less than 10 yrs	Medium: b/n 10 & 30 yrs	Long: above 30 yrs	Poor	Medium	Better-off	
Climate change	78.3	83.1	50.0	81.8	85.0	81.7	91.7	78.9	40.0	85.7	91.4	88.9	77.9	100.0	82.3
Total															100.0
Chi- square	X = 0.582		X = 0.021			X = 0.95			X = 0.000			X = 0.106			
Perception on temperature															
Increases in temperature	89.8	91.3	81.8	90.0	100.0	86.7	91.7	93.0	73.3	91.4	92.3	100	91.6	83.3	90.1
Decreases in temperature	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
I don't know	2.8	2.3	9.5	7.7	4.3	6.7	4.2	5.3	13.3	3.3	2.9	2.8	3.6	1.7	4.3
I didn't given enough attention	8.7	5.1	2.1	3.3	1.3	6.7	4.2	5.3	13.3	4.4	5.7	13.9	3.2	0.0	5.7
Total															100.0
Chi- square	X = 0.446		X = 0.122			X = 0.733			X = 0.133			X = 0.231			
Perception on precipitation															
Increases in precipitation	18.6	21.7	10.0	8.2	4.3	13.3	16.7	26.3	13.3	22.0	14.3	16.7	10.6	11.5	19.1
Decreases in amounts of rain	26.1	26.3	40.0	25.0	27.3	38.3	25.0	14.0	26.7	24.2	31.4	47.2	17.9	30.0	26.2
Changes in timing of rains	43.5	33.9	32.5	50.0	54.5	33.3	25.0	42.1	60.0	33.0	31.4	16.7	41.1	50.0	35.5
Increases in frequency_ drought	8.7	21.2	10.0	18.2	20.0	15.0	33.3	17.5	0.0	20.9	22.9	19.4	18.9	20.0	19.1
No change	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total															100.0
Chi- square	X = 0.539		X = 0.236			X = 0.030			X = 0.259			X = 0.013			
Experienced the hazards	100.0	99.2	100.0	99.2	100.0	98.3	100.0	100.0	100.0	100.0	97.1	97.2	100.0	100.0	99.3
Total															100.0

Source: Field survey of 2017

Table 3. Relative frequency of adaptation strategies to climate change and variability by sex, age, farming experience, education, and wealth status (By % of respondents)

Response strategies employed by farmers	Perception by sex (By %)		Perception by age (By %)			Perception by education (By %)			Perception by farming experience(By %)			Perception by wealth status (By %)			Total (n = 241)
	Male	Female	0-35 yrs	35-60 yrs	65+ yrs	Illiterate	Able to read & write	Primary level	Short: > 10 yrs	Medium: b/n 10 & 30 yrs	Long: > 30 yrs	Poor	Medium	Better-off	
Change crop variety	91.6	100	100	92.9	90.0	95.3	100	87.5	100.0	90.0	96.6	96.2	92.5	85.7	93.0
Shift planting dates	100	99.2	100	99.2	100	98.3	100	100	97.1	100	100	97.2	100	100	99.3
Adjust to crop management	83.3	77.1	100	73.5	100	78.1	91.7	68.8	80.0	64.5	95.8	87.0	66.7	100.0	78.3
Diversify crops	70.0	66.7	100	69.4	62.5	81.2	58.3	56.2	60.0	71.0	70.8	69.6	73.3	57.1	70.0
Adjust to livestock management	77.1	76.5	100	75.0	80.0	83.7	64.7	75.0	100	76.7	69.0	71.4	77.6	76.9	77.0
Use of chemicals	83.3	77.1	100	73.5	100	78.1	91.7	68.8	80.0	64.5	95.8	87.0	66.7	100	78.3
Move to a different site	4.3	9.3	13.6	7.5	16.4	8.3	12.5	7.0	11.5	9.9	8.5	12.2	4.2	10.0	8.5
Soil & water conservation	52.1	58.3	33.3	51.0	75.0	46.9	58.3	62.5	40.0	32.3	83.3	47.8	50.0	85.7	53.3
Move to distant area in search of temporary work	21.7	25.4	20.0	25.0	27.3	21.7	25.0	28.1	20.0	28.6	17.1	40.0	27.8	22.1	24.8
Diversify from farming- none farming	21.2	21.7	18.2	20.0	40.0	5.3	33.3	31.7	26.7	19.8	22.9	9.5	20.0	52.8	21.3
Change quantity of land	55.4	70.6	33.3	59.5	60.0	65.1	47.1	55.0	63.6	68.3	34.5	50.0	61.2	57.1	58.0
Off-farm activity	22.9	21.7	20.0	18.2	5.0	15.0	37.5	24.6	22.2	23.2	20.0	28.6	24.2	0.0	22.7

Source: Field survey of 2017

Table 4. Result of Heckman's Probit Model of farmers' perception of and adaptation to climate change (n = 241)

Farmers' Perception to Climate Change (Selection equation)				Farmers' adaptation to climate change (Outcome equation)		
Explanatory variables	**Coefficient**	**Marginal Effect (dy/dx)**	**P-value**	**Coefficient**	**Marginal effect (dy/dx)**	**P-value**
Sex of HH head	0.5186504	0.2005671	1.16	1.180447	0.353656**	0.037
Age of HH head	0.3007355	0.0905735***	0.000	0.912604	0.148937***	0.010
Access to extension service	0.9084681	0.3494685**	0.022	7.132573	0.0187718***	0.011
Access to climate information	1.005149	0.3609058***	0.005	1.303741	0.4382108***	0.019
Wealth status of the HH	0.0573928	0.0171946	0.867	1.186017	0.3096302***	0.008
Involvement in nonfarm income	0.5259865	0.1419888	0.260	1.344804	0.5364653**	0.038
Access to credit service				1.473219	0.4951756***	0.000
Increase in temperature				1.24123	0.4945397***	0.025
Change in timing of rainfall				2.313727	0.890042***	0.000
Experience occurrence of hazards	0.1290608	0.0514863	0.760	1.315029	0.5058639***	0.014
Agro-ecology	0.77624	0.2616187*	0.046	0.0417658	0.0112746	0.617

, ** & * Significant at p<0.1, p<0.05 & p<0.01 respectively*
Source: Field survey of 2017

Agro-ecology: the local agro-ecology where the surveyed people living was generally expected to positively influence the perception of farmers to climate change and variability. As guessed, farmers living in different agro-ecology perceived the change in climate of their locality at 5% of significance level. Hence, one move from midland to lowland agro-ecology increased the perception of farmers to climate change and variability by 26.16% (Table 4). Having better perception to the climatic condition of the area implies existence of good chance to decide on adoption of various adaptation strategies. This is in line with the research conducted by [29,33]. The possible explanation for this is that for farmers who live in lowland agro-ecology, a little change in climate of the area led to serious impact on their living and thereby increases the perception of farmers to climate change in the surveyed area. That is why the perception of farmers living in the lowland agro-ecology is better than to farmers who living in midland agro-ecology to climate change.

4. CONCLUSIONS AND POLICY IMPLICATIONS

Ethiopia has been among extremely vulnerable nations to the impact of climate change and variability. Dependence on sensitive sectors for both economic development and livelihood reliance has been believed as key reason of the country. Moreover, dominance of smallholder farmers and which is also predominantly rain fed on which more than 85% of the rural population depend attracted much recognition as a cause for vulnerability of communities in the region. As result, the primary aim of this study was to analyse the perception of smallholder farmers to climate change and variability and their local response strategies to the perceived change in climate. Analysing the factors that influence both their perception to climate change and decision to adapt is one more focus of this study.

The result showed that farmers well perceived the existence of observable changes in the climate of their locality without showing significant difference between the agro-ecology and to their socio-economic variation. Their experience of increase in temperature, a decrease in the amount of rainfall, and change in the timing of rainfall, increase in the frequency of drought and its consequent hazards and devastated impact that occurred across the agro-ecology were the most common indication to perceive change in their community. Increase in temperature coupled with reduction in the amount of precipitation and its resultant impact in terms of frequent drought were reduced the productivity of the smallholder farmers.

Based on their observation of physical environment and impact born perception, farmers attempted to adapt climate change and variability through employing various strategies. In addition

to the impact of climate change and variability in smallholder farmers of the surveyed community were also challenged with socioeconomic factors to adapt. Particularly, the poor farmers, farmers with short period of farming experience, headed with women and young were the most challenged segments of the farmers to adapt the impact of climate change and variability. Because, it requires financial capital to invest, having updated information on the climate situation of their locality, management perception of farming system and access to new technologies in the sector to adapt.

Thus, there should be local context need oriented intervention be taken by the government of local as well as national and other non-government agencies as well. Hence, more work should be done in developing a policy that is targeted to reduce the impact of climate change and vulnerability of households. Therefore, sound policy can exert much more effort in increasing the resilience of smallholder farmers equally reducing the factors that hinders their ability from adapting to perceived change in climate. These must also be conscious and take in to account the future projections of climate change.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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