

Comparing Farmers' Perception of Climate Change and Variability with Historical Climate Data: The Case of Ensaro District, Ethiopia



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Abstract

This study was aimed to compare farmers' perception of climate change and variability in three kebeles of Ensaro district of Amhara Regional State of Ethiopia with 30 years meteorological data. One hundred and twenty-four sample household heads were selected, of which 22 participants were female headed households. A FGD with six participants in each kebele were held and key informant interviews were held at the district level. Both qualitative and quantitative methods of data collection and analysis were used to compare with 30 years historical climatic data from the gridded satellite image of the study area. Also, logistic regressions were used to estimate factors that influence farmer's perception of climate change and variability and reconnaissance drought index method was used to classify drought condition of the area. The findings showed that, the average temperature of the district showed an increment by 1.02°C in the past three decades with an annual increment of 0.034°C whereas the annual rainfall of the district showed a decreasing trend with a variation of 12.7 % from the mean in the period 1987-2016. In line with this, 100%, 87.5% and 83.3% of respondents in lowland, highland and midland agro-ecologies, respectively, perceived that temperature has shown an increasing trend and 89% of respondents recognized the decreasing trend of rainfall with shortened period of its distribution. There is an agreement between meteorological data and farmers' observation that the onset of the rainy season is shifting: it was June first before ten years, and it has been extended to first week of July at present and accompanied by an increasing drought frequency. The binary model results revealed that the respondent's age, educational status, access to extension and farm experience have a positive and significant effect on farmer's perception on climate change. Moreover, farmers living in lowland agro-ecology have been aware of climate change as compared to midland and highland agro-ecologies. This is due to the fact that lowland agro-ecology is already hotter and a marginal change in temperature could be perceived easily.

Keywords: Climate change; Perception; Climate data; Barriers

Introduction

Climate change is the primary environmental issue today and will continue so in the future at a global level. United Nations Framework Convention on Climate Change [1] has defined climate changes as a change of composition of the global atmosphere that is attributed directly or indirectly to human activity in addition to natural climate variability observed over comparable time periods. In the past couple of decades, climate change has become increasingly apparent that it is already happened, happening, and will continue to happen, bringing with its local impacts on people's livelihoods [2]. The Intergovernmental Panel on Climate Change concluded that, climate variability is already happening all over the world with its multi-faceted effects on human society and the environment. Climate variability will certainly have effect on sustainable development of biodiversity, water, forests, land and oceans as well as in relation to various sectorial activities [3]. There are spatio-temporal variations in the vulnerability and adaptive capacity among countries, regions, economic sectors

and social groups [4]. In this regard, all African countries are vulnerable to climate change and Ethiopia in particular is among the most vulnerable countries to climate variability with little adaptive capacity. Climatic and ecological changes have resulted in several negative consequences on livelihood, health, economy and environment of the people in Ethiopia [5]. Recurrent drought, famine and flood are the main problems that affect millions of people in the country almost every year [6]. The livelihoods of smallholder farmers are mainly dependent on agriculture and natural resource which are highly sensitive to climate change. The impact of climate change is more aggravated by poverty and the impact will be intense when it is combined with other environmental changes [7,8]. But it is possible to reduce adverse effects of climate change and variability by formulating effective and efficient adaptation strategies.

In different nations small holder farmers try to respond to the changing climate via different indigenous coping and adap-

tation mechanisms [9-14]. But success of any adaptation measures would depend on a good farmers' perception about climate change and variability [15-21]. Households that have a better perception on climate variability can cope and adapt to the changing climate than those who did not perceive it [1]. Most farmers in Africa perceive the increased temperature and declined precipitation [20]. In line with this, majority of the farmers who have been contacted in Ethiopia are aware of climate change and perceived an increase in temperature and decrease in precipitation [22]. However, the perception of climate change is shaped by varying cognitive structures caused by socioeconomic and cultural differences that expose people to differing attitudes, values and interests [23]. Therefore, farmers' perceptions of climate change and variability and its effects are influenced by psychological and socioeconomic differences which will limit their response to climate change [24]. In the past, many different studies were done in different corners of Africa with regards to human perception of climate change and its impacts [25-28] and most of them have confirmed that, the farming community perceived the changing of climate and trying to implement soft and hard adaptation strategies [24,29]. However, perceived changes may not always reflect the reality, and climatic events or trends may be misinterpreted or wrongly remembered for a variety of reasons. Therefore, it is necessary to assess and analyze farmers' perception of climate change and variability and what did climate data really showed. So, this paper tried to assess and compare farmers' perception with metrological data in the study area.

Research Methodology

Description of the study area

Ensaro district is one of the 24 districts which are found in North Showa Zone of Amhara Regional State in Ethiopia. Geographically, the district is located between 9° 35' - 9° 55' N and 38° 50' - 39° 5' E with an average elevation of 2435 meters above sea level. The district has one urban kebele and eleven rural kebeles. Based on the 2007 national census conducted by the Central Statistical Agency (CSA) of Ethiopia, the district has a total population of 58,203, of which 29,888 were male and 28,315 female; 3,164 (5.44%) were urban inhabitants. The district's total land coverage is 44,217.6 hectare including undulating areas covering about 50%, flat plains 40%, mountainous and others 10%. According to the district's administration office and community classification, the district's agro-ecology is subdivided into *lowland* (33%), *midland* (46%) and *highland* (21%). The vegetation is dominated by scattered trees such as the *Croton macrostachyus*, *Olea capensis*, *Euclea schimperi*, acacias (*Acacia* spp.), *Eucalyptus viminalis* and *Eucalyptus globules* etc. The area is also characterized by a bimodal rainfall distribution with a distinct rainy season lasting from May to September. The average annual rainfall varies between 900 to 1500mm and average temperature is in between 18°C-30°C. Although agriculture is the main economic activity, many households are engaged in activities such as trading, selling

of fire wood and charcoal and livestock rearing which constitute the main source of cash income (Figure 1).

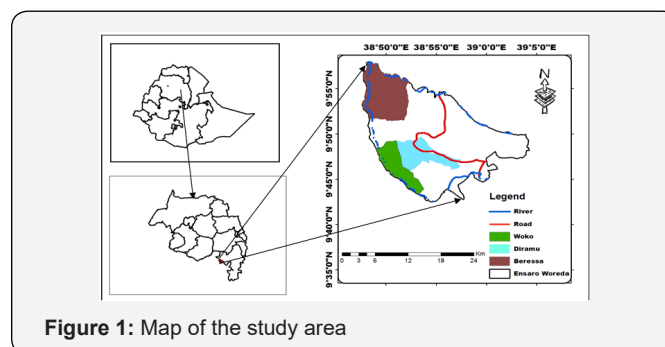


Figure 1: Map of the study area

Sampling and sample size

The sample kebeles were purposively selected from all agro-ecological zones of the district: Beressa kebele from *Lowland*, Woko kebele from *midland* and Diremu kebele from *Highland* agro ecologies. Climate change hazards like flood, drought and landslide are more severe in the selected kebeles of the district. The participants in this study included: the local people (male and female including youths), government representative, and religious leaders of sample kebeles, and concerned officials from the district. The sample size was 124(10%) out of 1232 total household heads in the sampled kebeles. Both primary and secondary data sources were used. The primary data were collected through questionnaire, interview and focused group discussion. The researcher selected FGD and KI respondents in each kebele who are socially respected within society and are known to have better knowledge on the present and past environmental, social and economic status of the study area. At each kebele, one focus group discussion was held with 6 participants in each discussion group and key informant interviews with 10 community representatives. Secondary data were collected from published and unpublished documents identified from government offices, National Meteorological Service Agency (NMSA), Central Statistical Agency and Addis Ababa University. Gridded satellite data was used for the monthly rainfall and maximum and minimum temperature for the period 1987 -2016.

Data analysis and presentation

Data obtained from various sources were analyzed using qualitative and quantitative data analysis techniques. The Qualitative data were narrated and interpreted. The quantitative information gathered using interviews were analyzed using SPSS Version 23.0 statistical software. Errors related to inconsistency of data were checked and corrected during data cleaning. In addition, the quantitative data generated by questionnaire and from ENMSA gridded data had been analyzed using descriptive statistics. Descriptive statistics such as mean, frequency and percentage were used to characterize farmer's perception on long-term temperature and precipitation variability as well as various adaptation measures used by farmers, and barriers they face to adapt. Binary logit mod-

el was used to see the relationships between dependent and independent variables and reconnaissance drought index was used to characterize the drought condition of the study area.

Result and Discussion

Average annual Temperature

The average temperature of the study area has increased by 1.02°C in the period 1987-2016 with an annual increment of 0.034°C (Figure 2). On the other hand, maximum and minimum temperatures have increased by 1.5°C and 0.5°C respectively in the past three decades. Such trend of increase in temperature in the Ethiopian highlands is also reported [30].

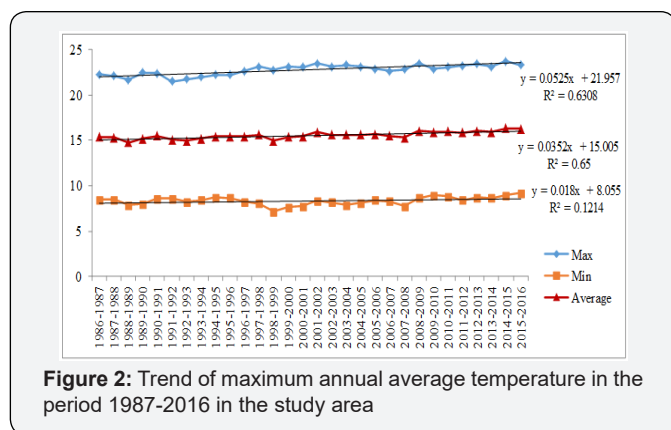


Figure 2: Trend of maximum annual average temperature in the period 1987-2016 in the study area

Average monthly and annual rainfall

The average annual rainfall of *Ensaro district* over the last three decades indicated somehow a decreasing trend (Figure 3). The annual average rainfall was 1175mm, with the maximum of 1487mm record in 1996, whereas the smallest average rainfall (764mm) was recorded in 2015.

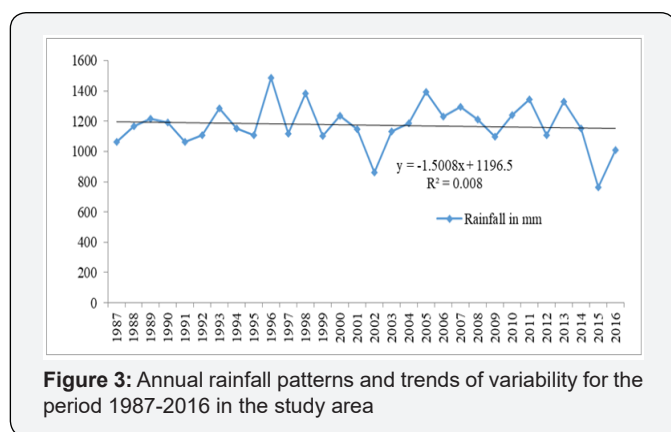


Figure 3: Annual rainfall patterns and trends of variability for the period 1987-2016 in the study area

Monthly rainfall distribution in the last three decades of the study area showed that, there was a prevalence of rainfall across months. Nearly 67% of the total amount of rainfall was recorded between July and September. The monthly pattern of rainfall distribution starts to decline from October until March that clearly reflects the prevalence of seasonality of rainfall in the study area (Figure 4).

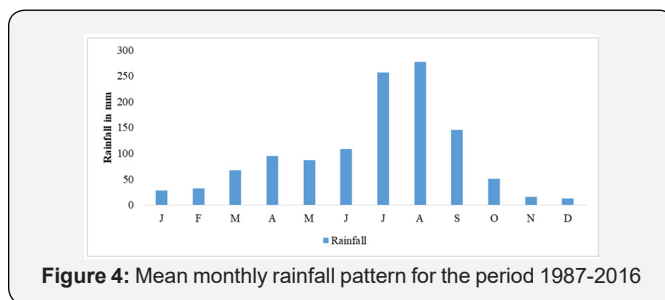


Figure 4: Mean monthly rainfall pattern for the period 1987-2016

Seasonal rainfall patterns

The analysis of seasonal rainfall in the study area showed a small/negligible variability with R^2 ranging from 0.014 for March-April-May (MAM)—Ethiopian spring season— to 0.037 for June-July-August (JJA)—Ethiopian summer season—during the period 1987-2016. In the same period, the rainfall has declined by 0.49 and 0.51mm per annum for MAM and DJF— Ethiopian spring season and winter seasons—respectively (Figure 5).

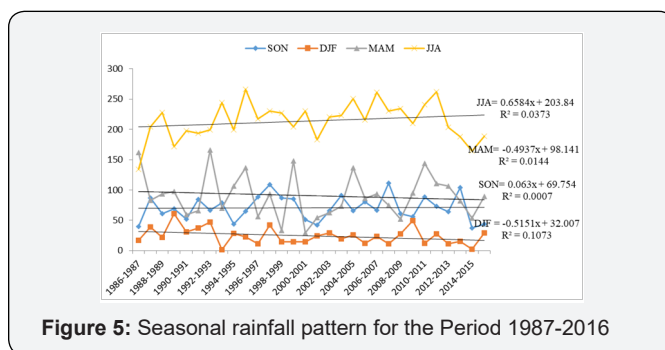


Figure 5: Seasonal rainfall pattern for the Period 1987-2016

Community perceptions of climate change and variability

Having better understanding of local people’s perception on climate change and variation is crucial to design appropriate adaptation and coping strategies [31]. It is important to have an insight of local people’s view on temperature and rainfall trends of change to screen locally available climate change and variability adaptation options. In line with this, FGD participants, key informants and respondents were asked to tell their understanding of climate change and source of information. About 95% of male and 55% of female respondents confirm that, there is climate change and variation in their locality. More than 69% of male and 59% of female respondents have had information on climate variation and the major source of information are radio, development agents and market places. Regarding to the perception of community to climate variability, majority of participants perceived the existence of the problem and their perception also related with their socio demographic variables.

Perception by Agro-Ecology and sex of household heads

People who live in lowland agro-ecology have perceived more because lowlands are already hotter and a marginal change in temperature can be perceived more easily [32]. In line with this, the result of this research also showed that farmers in *lowland* agro-ecology (92.8% of male and 66.7% of female from the sam-

ple) are more aware on climate change than farmers in *midland* (79.5% of male and 55.6% of female). About 77% of male and 43% of female respondents are aware of climate change in *highland* agro-ecology. The result showed that female headed households are perceived less because they are less access to information, technology and mobility. In contrary, male headed farmers have access to information due to mobility, decision making and their participation in training. In general, about 95% of male and 55% of female (88% of total the respondents) in all agro-ecologies are aware of climate change, while about 12% of respondents have no information or didn't have the knowledge of climate change.

Perception by age group

According to Amadou [33], farmers with high experience are more perceived climate change. In line with his argument, 60%, 89% and 94% participants found under age 20-40, 41-60 and >60 have understood the existence of climate variability in their kebeles respectively. The elder respondents perceived climate change very well due to their long experience in the area. Previous studies also indicate that, perception will increase when age of a household increases [22].

Perception by education level

Out of 45 illiterate respondents, 64.4% of them have observed the existence of climate variability, while 75% of those who read and write, 89.5% of those who reached primary school and 100% of the respondents that reached secondary school have perceived the existence of climate change and variability. The result showed that about 36% of the respondents that didn't perceived the existence of climate change and variability were illiterate and followed by those who have only informal education (25%). The educational level of farmers has a direct link with the perception to climate change and variability. Farmers with relatively higher education levels have opportunities to get information from schools, environmental clubs and other sources of information. Thus, farmers with higher educational level have better perception than farmers with lower levels of education.

Farmers' perception on temperature and rainfall variability

The result revealed that most of the respondents have perceived as there was long-term variability in temperature in Ensaro district over the past three decades. Almost 100%, 88% and 84% of the respondents in *lowland*, *highland* and *midland* agro-ecologies, respectively, have perceived that temperature is increased from year to year. On the other hand, about 13% and 17% of the respondents in *midland* and *highland agro-ecologies* felt that there is no change in temperature. The indicators of temperature variability perceived by the respondents were drying up of rivers and streams, crop damage by pests, newly introduced human and animal disease, and species shift to upper altitude, and introduction of new plant and animal species.

Key informant interviewees and FGDs discussants have recognized as there were variability in rainfall amount, its timing

and distribution in the study area over the past 30 years. This was substantiated by household respondents. About 97% of the respondents in *lowland* agro-ecology have recognized the change (the increase or decrease) of rainfall amount, while only 42% and 22% of respondents in *midland* and *highland* agro-ecologies have perceived rainfall change respectively. This shows that climate change is more pronounced in areas already have climatic problem. The survey results revealed that all the respondents have perceived long-term variability in pattern of rainfall amount and distribution. Most of the respondents indicated that rainfall amount in Ensaro district in the last 30 years showed a decreasing trend and variability whereas only few of the respondents reported that it has increased. The local community perceived the shift in the beginning of the spring rainfall from March to May. The perceived impacts of such variability in rainfall include emergence of pests and disease, interruption in crop calendar of such spring crop production for root crops and vegetables, death of livestock.

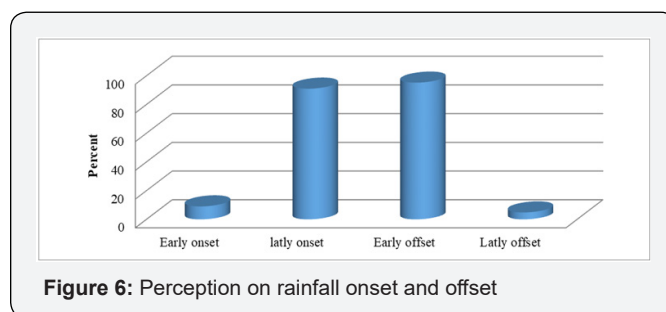


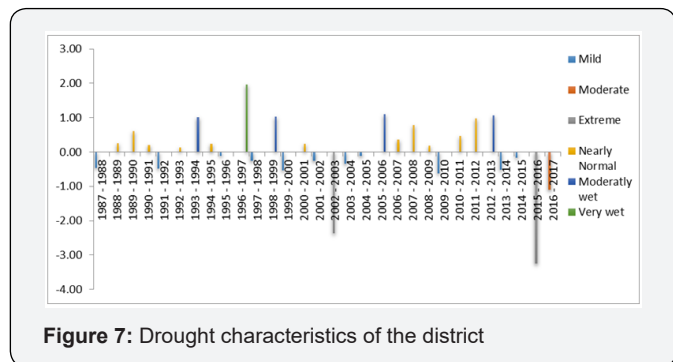
Figure 6: Perception on rainfall onset and offset

About 94% of interviewed farmers indicated that there is a long-term change in the start and end of the rainy season in the study area (Figure 6). About 91% of the respondents indicated that the onset of the rainy season has been shifted from the first week of June before 10 years ago to the first week of July in the current year. Its only 9% of the respondents reported that the dates of the onset are early. On the other hand, the end of the rainy season has shifted from October 1st week what was before 10-30 years ago to the 1st week of September and last week of August in current year which was agreed by 95% of the respondents. It was only 5% of the respondents who have a thought that the rainy season was ending late.

Drought prevalence

Climate changes will most likely increase poverty in Ethiopia [34]. Long term trends towards reduced rainfall, and recurring droughts, have played a role in weakening of Ethiopian economy [35]. About 94% of the respondents have well recognized the prevalence of drought in *lowland* agro-ecology, while nearly 63% in *midland* and 26% of the respondents in *highland* agro-ecologies have perceived the prevalence of drought (Figure 7). On the other hand, the increment of the frequency of drought is more perceived by respondents in *lowland* agro-ecology (89%) than respondents in *midland* (60%) and *highland* (23%) agro-ecologies. This shows that, climate change was not a problem in the *highland* agro-ecology of the study district. The results from the Reconnaissance Drought Index (RDI) showed that, there was an extreme drought

condition in 2015-2016 in Ensaro district with severe and moderate drought conditions in 2002-2003 and in 2016-2017 respectively.



Determinants of perception of climate change

A large number of local people consider that climate has become hotter and drier. All the respondents and most of the FGDs participants, experts and interviewed informants perceived changes in temperature and precipitation. The binary model results revealed that the respondent's age, educational status, access to extension and farm experience have a positive and significant effect on farmer's perception on climate change and adaptation. The results showed that a unit increase of the variables significantly increase the odds of having a good perception of climate change and variability (Table 1). On the other hand, sex of household heads, access to extension services, farm land size, access to market and access to credit have negative and significant effect on farmers perception on climate change in the study area.

Table 1: ANOVA: Factors that affect Farmers perception on climate change from binary logit model.

Factors	Attitudes on Climate Change		Feeling of Temperature		Rainfall Change		Encountering of Crop Failure		Occurrences of Drought	
	B(S)	Exp(B)	B(S)	Exp(B)	B(S)	Exp(B)	B(S)	Exp(B)	B(S)	Exp(B)
Age	0.197(.550)	1.302	.033(.490)	1.356	.759(.622)	2.135	.334(.735)	1.396	1.883(.074)	6.572
Sex	-1.015(.292)	0.759	-0.03(.975)	0.029	-0.5(.599)	0.694	-.469(.432)	0.626	-0.536(.346)	0.71
Education	0.784(.018)	2.062	-0.069(.865)	0.934	-.97(.225)	0.379	.611(.082)	1.842	.200(.574)	1.222
Family Size	-0.617(.111)	0.854	.103(.712)	1.108	.044(.890)	1.045	.612(.003)	1.542	.120(.351)	1.887
Access to Extension	.937(.308)	1.392	-.125(.903)	0.883	-.1(.894)	0.905	.273(.587)	1.314	.897(.063)	2.453
Farm Land Size	-0.257(.826)	0.293	-.640(.488)	0.527	-.407(.709)	0.502	-.661(.277)	0.516	-.352(.551)	0.703
Access to Information	-.310 (.745)	0.364	-1.27(.022)	0.569	.393(.683)	1.481	.409(.527)	1.506	-1.269(.048)	0.281
Access to Credit	0.888(.398)	2.431	-.479(.659)	0.619	.970(.339)	2.639	-.724(.353)	0.485	.354(.090)	1.258
Farm Experience	.289(.881)	1.336	-.991(.539)	0.371	1.34(.461)	3.832	.239(.816)	2.787	.784(.461)	1.456
Extra Income	1.286(.402)	3.617	-.501(.552)	0.606	-.06(.966)	0.058	1.256(.077)	3.513	.715(.291)	2.043
Access to Market	-.086(.919)	0.917	-.761(.433)	0.467	-.80(.360)	0.232	-.105(.867)	0.9	.702(.252)	2.017
Constant	-4.338(.365)	0.013	2.079(.680)	7.999	-8.9(.051)	0	1.326(.684)	3.767	-2.059(.463)	0.128

Exp(B)====odd ratio S=====significant

Farmers' perception VS empirical meteorological data

Individual's perception of climate change is highly personal, place-based, and influenced by a number of factors. This paper tried to see how farmers perceptions of climate change are related to historical trends in climate. Farmer perceptions of climate change varied considerably and were not systematically consistent with the direction and significance of climate trends calculated from the observational record, lending support to the idea that other personal and environmental factors are important for determining perceptions. In this regard, like any farmer in every developing country, the majority of farmers in the study area be-

lieve that the climate has changing. The respondents claimed that temperature has increased, and rainfall has decreased through time. The study by Mekonnen et al. [25] in Arsi Negele district of the central rift valley of Ethiopia showed that the total average temperature shows an increasing trend while the rainfall shows a decreasing trend. In line with this argument, almost 100%, 88% and 83% of respondents in *lowland*, *highland* and *midland* agro-ecologies, respectively, have perceived that temperature is increased from year to year. On the other hand, the meteorological data indicated that the average temperature of the study area has increased by 1.02°C in the past 30 years with an annual increment of 0.034°C. In regard to rainfall, about 97% of the respondents in *lowland* agro-ecology have recognized the change (the increase or

decrease) in rainfall amount, while only 42% and 22% of respondents in *midland* and *highland* agro-ecologies, respectively, have perceived rainfall changes over the last three decades. Some of the mentioned reasons for their perception of the long term decrease in rainfall were day-to-day experiences with rainfall variability, increasing dry spells, time shifts in onset and offset of rainfall and its distribution rather than on average quantities of annual rainfall. However, the actual data have not shown a significant change in trend, especially rainfall. On the other hand, about 94% of the respondents in lowland agro-ecology have well recognized the prevalence of drought, while nearly 63 and 26% of the respondents in *midland* and *highland* agro-ecologies, respectively, have perceived the prevalence of drought. The increasing frequency of drought was more perceived by respondents in *lowland* agro-ecology. The results from the Reconnaissance Drought Index (RDI) showed that, there was an extreme drought condition in 2015-2016 in Ensaro district with severe and moderate drought conditions in 2002-2003 and in 2016-2017 respectively.

The results of the regression analysis showed that age, educational status, access to extension and farm experience have a positive and significant influence on farmers' perception of climate change and variability. This positive relationship between the perception of climate change and access to extension services indicates that having extension advice is very likely to increase the farmers' awareness of climate change and variability [36]. Although getting extension services would help to build farmers' knowledge, they still had their own perception on climate change [37]. In addition, farmers' perception of the local environment could be related to the topography of the area which exerts a strong influence in the agro-ecology. In line with this, farmers living in lowland areas were more likely perceived climate change than those in the midlands and highlands [36]. The results of this study showed that farmers in lowland agro-ecology have better perception on climate variability than farmers in highland agro-ecology.

Conclusion

Most of the respondents, FGD and KI participants indicated that, temperature is becoming increasing from time to time in the past three decades in the district and rainfall is in a decreasing trend in amount, duration and intensity. A number of farmers in the study area are aware on the late onset and early offset of rains and the increasing drought frequency which are in accord with empirical meteorological records. However, farmers give much more importance to the intra-annual variability of rainy season characteristics such as rainfall intensity and distribution than the total annual rainfall. Moreover, there are several factors that determine farmers' perception on climate change. The results of binary logit model have revealed that the respondent's age, educational status, access to extension and farm experience have a positive and significant effect on farmer's perception on climate change and/or variability. The results of the study direct the need in capacity development programmes like climate -smart agro

ecosystem management trainings for farmers to cope with the changing climate. Therefore, the government could build the capacity of agricultural extension systems and strengthen climate change education scheme [24,38] with ICT innovations such as cell phone applications and up to date early warning system by integrating information from both the ingenious and scientific climate prediction methods.

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