International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

Smallholder Farmers' Perception and Their Adaptation Strategies to Climate Variability and Change in Ale and Bure Districts of Ilubabor Zone, Southwest Ethiopia

Solomon Tadesse[a*], Venkateswarlu Madduri[b]

[a,b]*Department of Geography and Environmental Studies, Mettu University, P.O. Box 318, Mettu, Ethiopia*
[a]*Email: stadesse37@gmail.com*

Abstract

This study examined smallholder farmers' perception of climate change and their adaptation strategies in Ale and Bure districts of Ilubabor zone, southwest Ethiopia. A cross-sectional survey research design was employed to collect information from 498 randomly selected households in six rural kebeles. A two-stage random sampling technique was used to select the sampled households. Climate data on rainfall and temperature from the meteorological station to each study district covering the period from 1983 to 2017 was also used for this study. Descriptive statistics and Mann-Kendall trend test were used to analyze the data. Results revealed that smallholder farmers perceived long-term changes in climatic parameters such as temperature, rainfall amount, frequency of drought and number of rainy days over the past three and half decades. The Mann Kendall test and Sens's slope estimator test also indicated that mean annual rainfall has a significant negative trend while mean annual temperature revealed a statistically significant increasing trend. Changing planting dates, crop diversification, planting shade trees, agroforestry systems, soil and water conservation practices were identified as major important adaptation strategies implemented by farmers. Therefore, it is concluded that there had been a significant change in rainfall and temperature in the study area and farmers engaged in various climate response strategies. This study suggests that there is a need to develop more effective climate change adaptation strategies that will enhance the resilience of farmers to a changing climate.

Keywords: adaptation strategies; climate trend; climate variability.

---

* Corresponding author.

1. Introduction

The world's climate is continuing to change at rates that are projected to be unprecedented in recent human history (Intergovernmental Panel on Climate Change [1]. The Fifth assessment report of the IPCC [2] confirms that the global average temperature has increased by 0.748^{0}C over the last 100 years and the projected rise in warming by 2100 is about 1.8-4.8^{0}C. There are now strong evidences, which show that the earth's climate is changing mainly as a result of the increasing concentration of greenhouse gases in the atmosphere that are emitted from various human activities [3] and the change is now evident from observations of increases in global average air temperatures, widespread melting of snow and ice, and rising global average sea level [2]. Developing countries are most vulnerable to climate change though they are only contributing 10% to the annual global carbon dioxide emissions [2]. Countries in Africa are among the most vulnerable globally to the effects of climate change because of the dependence of much of the population on agriculture, particularly rain-fed agriculture, widespread poverty that renders them unable to withstand climate stress and their limited capacity to adapt to the impacts of this climatic change [4]. Ethiopia is one of the horns of African countries which has already suffers from climate variability and extreme events. For instance, agriculture in the country is exposed to the effect of failure of rains or occurrence of successive dry spells during the growing season, which could lead to food shortage [5]. Similar to the Ethiopian highlands the study area smallholder coffee-growing farmers' who dependent on a coffee economy for their livelihoods are also vulnerable to the risks associated with climate change. For instance, climate changes such as shifts in the rainy season and variations in temperature and precipitation can negatively affect coffee plant physiology, flowering and fruiting resulting in reduced yields [6]. Understanding of smallholder farmers' perception of climate change and their adaptation strategy is vital for designing and implementing more effective climate change adaptation policies and programs. A number of empirical studies have shown that smallholder farmers in developing countries can respond to climate change by adapting to its impacts, and thereby reducing the rate and magnitude of the climate change [7]. Existing studies identified a number of adaptation measures at different levels, both micro and macro [8]. For instance, a study by [9] identified a number of household level adaptation strategies such as planting high-yielding crops, altering the timing of operations and climate stress-resistant crop varieties, soil conservation and planting trees in the Nile Basin of Ethiopia. However, some of the adaptation methods are highly localized and cannot be directly adopted and implemented in other regions or agriculture settings. Other studies identified migration and crop diversification as main strategies to reduce vulnerability of climatic related risks [8]. Although smallholder coffee growing farmers are vulnerable to climate variability and change, as elsewhere in the Ethiopia, yet their perceptions and adaptive responses to climatic related risks are not largely documented and empirically studied [8]. According to this author, so far, a number of climate change related studies have focused on the Nile Basin regions of Ethiopia, while other areas were paid less attentions. This suggests that there is a need to study the other parts of the country in order to fill the spatial knowledge gap of information. Furthermore, there are little empirical studies on the patterns of rainfall and temperature change, perceptions and adaptive responses being undertaken by coffee growing farmers in the study area. In this regard, [5] suggested that a better understanding of the local dimensions of climatic change is very essential to design appropriate adaptation strategies that can mitigate the adverse impact of climate change which consequently help to reduce vulnerability. Therefore, this study, seeks to investigate perception of climate change and their adaptive responses by smallholder farmers' to climate variability and change in Ale and Bure districts of Ilubabor zone southwest Ethiopia.

2. Materials and Methods

2.1 Description of the study areas

The study was conducted in Ale (8°0'-8°17' N latitude and 35°25'-35°49' E longitude) and Bure (8°6'-8°31' N latitude and 34°57'-35°17' E longitude) districts, which is located in Iluababor Administrative zone of the Oromia National Regional State, southwest Ethiopia (Fig. 1). The two districts cover a total area of 1632 km^2 with a total population of 140,021 and average population density of 86 persons/km^2 Central Statistical Agency [10]. According to the Ethiopian traditional agro-climatic classification system, which mainly relies on altitude and temperature, Ale is in the *woinadega* (midland) agro-ecological zone while Bure is in the *Kolla* (lowland) agro-ecological zone. The elevation of Ale ranges from 1593 to 2049 m above sea level while it is 619 up to 1844 m above sea level for Bure district. The study districts are characterized by diverse topographic conditions like rugged terrain, deep gorges and extensive dissected plateaus. The common vegetation types in the districts include *Albizia gummifera*, *Millittia ferruginea*, *Pouteria adolfi-friederici*, *Schefflera abyssinica*, *Sapim ellipticum*, *Cordia-African and Acacia species* [11].

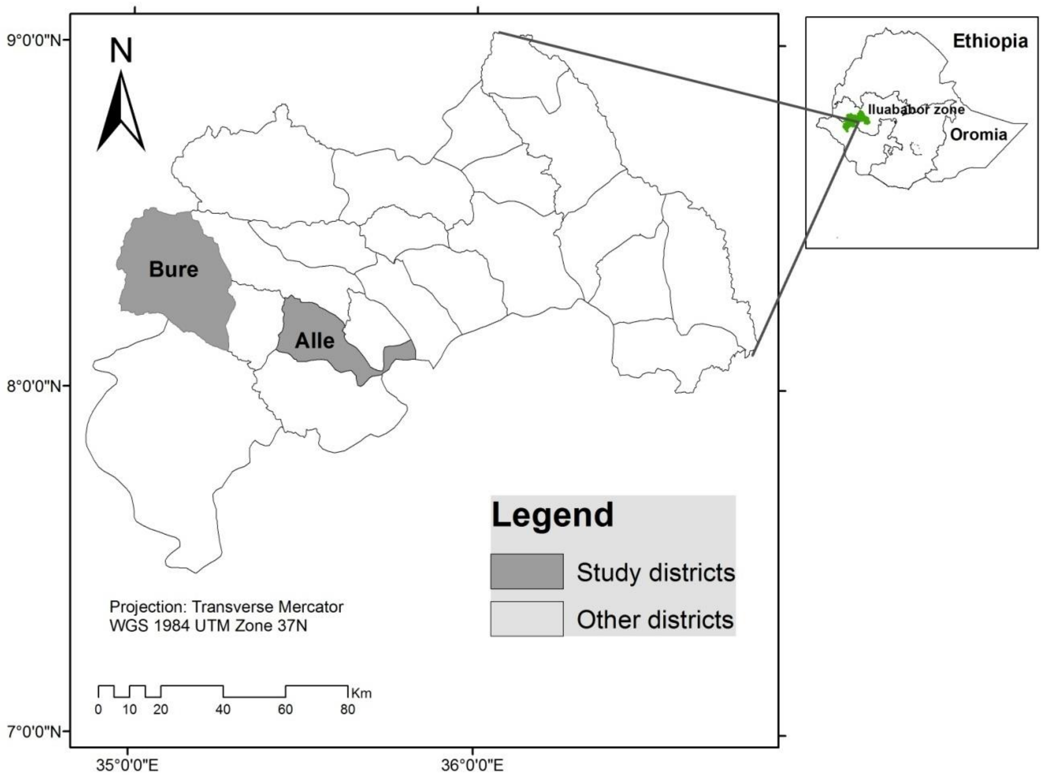

Figure 1: Location map of the study area

Based on the FAO/UNESCO soil classification system, dystric nitisols (red-basaltic soil) dominated the study area whilst considerable proportion of dystric gleysols and orthnic solonckaks are also present. Climatically, the districts fall within midland and lowland agro-ecological zones that experiences hot and humid climatic conditions. The mean annual rainfall and mean annual temperature are 1836 mm and 19^0C respectively for Ale district and a mean annual rainfall and mean annual temperature are 1340mm and 22^0C respectively for Bure district (National Meteorological Agency [12]. Agriculture is the main economic activity and source of livelihood in the study area. The farming system is mixed crop-livestock production on a subsistence level. The major cereal crops grown in the area include maize (*Zea mays*) and sorghum (*Sorghum bicolor*). Maize production constitutes the largest of the total food crops. Livestock is also closely integrated in the farming system and provide food and household income. collection of forest products are also the main livelihoods of most local peoples.

2.2 Sampling procedure and sample size

The study employed a two-stage sampling technique with a combination of purposive (to select sample districts) that have different agro-ecological zones and random sampling (to select sample rural *kebeles* and household heads). In the first stage the sampling procedure, two districts, namely Ale from *woinadega* (midland) and Bure from *Kolla* (lowland) agro-ecological zones were purposively selected for the study because to capture variations across agro-ecology. Then, from each district three rural *kebeles* (the smAlest administrative unit in Ethiopia) was randomly selected for the study. In the second stage, using the list of household heads from the respective rural *kebeles* administration offices, sample size was determined through probability proportional to size technique, representing a sampling intensity of 15%, as recommended by [13]. A total of 498 households were randomly selected, including 251 from Ale district (midland) and 247 households from Bure district (lowland), respectively. A lottery method was used for all of these random selections

2.3 Data collection methods

The data for this study were obtained from 498 household heads surveyed in the two sampled districts using a structured household survey questionnaire made between April and December 2018. A cross-sectional survey research design was employed to collect necessary information related to demographic and socio-economic characteristics of the respondents, farmers perceptions of climate change and local adaptation strategies using a structured household questionnaire survey. The questionnaires were pre-tested and then administered to the sampled household heads with the assistance of six trained enumerators. Enumerators were recruited based on their educational background, familiarity with the area and previous experience in data collection. All the enumerators were closely supervised throughout the data collection processes. In addition, key informant interviews and focus group discussion with knowledgeable individuals were undertaken using semi-structured checklists to generate in-depth qualitative information. Accordingly, six focus group discussions were conducted with seven participants in each sampled rural *kebele* at community *kebeles* office. Participants were representing diversity in terms of age, educational level, gender and economic status. The discussions covered topics such as smallholder farmers' perceptions of climatic trends over the past 34 years, indicators of climatic change and local adaptation strategies used by farmers in response to climatic-related risks in their locality. Furthermore, 22 key informant interviews with knowledgeable farmers, experience rich experts from the districts agricultural and rural development offices and Development Agents (DAs) working in the target rural *kebeles* were conducted. Selection of participants for focus group discussions and key informants were done through purposive sampling to obtain information that is more detailed. The qualitative data gathered through focus group discussions, key informant interviews and field observation were used to consolidate and triangulate the data obtained through household survey. Moreover, available historical climate data on rainfall and temperature from the nearest meteorological station to each study districts, covering the period from 1983 to 2017 were used for this study.

2.4 Statistical data analysis

The quantitative data generated by a structured household questionnaire survey were organized and entered into the Statistical Package for the Social Sciences (SPSS) version 23 for analysis. Descriptive statistics (frequencies, percentages, means, and standard deviations) were used to summarize and categorize the quantitative data gathered. The climatic data (rainfall and temperature) was analyzed for trend detection in XLSTAT, 2018 using Mann-Kendall trend test. Mann-Kendall trend test has been used to detect the presence of monotonic (increasing or decreasing) trends in the study area and whether the trend is statistically significant or not. Since there are chances of outliers to be present in the dataset, the non-parametric Mann-Kendall trend test is useful because its statistic is based on the (+ or -) signs, rather than the values of the random variable, and therefore, the trends determined are less affected by the outliers [14]. For this study, trend analysis has been carried out on annual bases. Sen’s slope estimator is also used to evaluate the direction of trend for understanding the changes in the climate parameters. A p-value (probability value) of ≤ 0.05 was considered statistically significant for inferential quantitative data analyses.

3. Results and discussion

3.1 General characteristics of the respondents

Table l presents the summary of some demographic and socio-economic characteristics of the sample respondents. Overall, the respondents comprised 24.7% female-headed households and 75.3% male-headed households with age ranging from 21 years to 74 years and an average of 41.3 years. The average farm experience is about 15.6 years. The marital status of the respondents at the time of the survey showed 74.3% were married while 13.9% were singles who had never been married. The average family size was 5.9, which was higher than the regional mean family size of 5.4 [15]. With respect to educational level, most of the respondents (61.8%) had no formal education and the remaining 38.2% had formal education. The average number of livestock owned by sampled respondents was 5.5 Tropical Livestock Units (TLU). Land is the most important livelihood asset of households in the study area, as it is elsewhere in rural Ethiopia. On average, the respondents possessed about 1.84 ha, which is larger than the national average of 1 ha [15].

Respondents were asked about their observations of changes in the local climatic conditions over the past three and half decades. Results from the farmers’ perceptions regarding changes in the climatic variables are presented in (Table 2). Majority of the respondents in this area are experiencing irregularities in the climate as they have been farming there for many years. Findings from household survey indicated that the amount of rainfall in the study areas has generally decreased during the last 34 years as reflected by a large proportion (88.8%) of respondents (Table 2). This result further supported by FGDs and key informants interview as they reported rainfall had become highly variable and more erratic.

Table 1: Demographic and socio-economic characteristics of the sampled respondents

Household characteristics	Values
Gender (%)	
Male	75.3
Female	24.7
Age (Mean ± SD)	41.3±10.8
Education level (%)	
No formal education	61.8
Formal education	38.2
Farming experience (Mean ± SD)	15.6±6.9
Family size (Mean ± SD)	5.9±1.5
Landholding size in ha (Mean ± SD)	1.84±0.6
Tropical livestock unit ownership (Mean ± SD)	5.5±3.4

Smallholder Farmers' Perceptions of Climate Variability and Change

Table 2: Farmers' general perceptions of climate change trends over the last 34 years

Climatic variables	Responses (%)		
	Increased	Decreased	Not change
Rainfall	6.8	88.8	4.4
Temperature	94.2	2.6	3.2
Frequency of drought	83.1	6.3	10.6
Number of rainy days	7.6	84.1	8.3
Floods after rain	87.4	5.4	7.2

Source: Field survey, 2018

Similarly, a considerable number of the respondents (94.2%) in the study districts were received temperature was increased over the past 35 year periods. The respondents' perceptions of rising temperature were in tandem with actual climate data recorded in the nearby meteorological stations in the study area. This result is in agreement with findings of [16] who reported that most of the farmers perceived that temperature is increasing and has become unbearable especially during the past two decades in India. Several empirical studies in other parts of Africa have also reported that an increase in temperature and decrease in precipitation over the last two decades. For instance, a study conducted by [16] in central highlands of Ethiopia reported that an increased average temperatures and a decreased of annual average rainfall amount. Reference [5] in the highlands of Ethiopia reported similar results. The result obtained in this study is thus similar to the one conducted in India [17], which report that decreasing of rainfall and its unpredictable behaviour and resultant dry spells during cropping season and resultant dry spells. With regard to frequency of drought, 83.1% of the respondents stated that they had observed frequency of drought over the last decades. Findings from key informant interviews and focus group discussions confirmed that there are widely held perceptions of increased frequency of drought and decreased number of rainy days along with other local environmental changes. Furthermore, they identified personal observation, radio and television as the most frequently available sources of information for farmers in this study area.

3.2 Trend analysis of major climatic parameters

Precipitation and temperature are two of the most important variables in the field of climate sciences and hydrology frequently used to trace extent and magnitude of climate change and variability [2]. Reference [18] emphasized that in countries where their economy is heavily dependent on low-productivity rain-fed agriculture, rainfall trends and variability are frequently mentioned factors in explaining various socioeconomic problems such as food insecurity. Analysis of the long-term climate data over the past 34 years, covering periods from 1983 to 2017 revealed that the climate change is happening. This climate trend is matching with the results of household's perceptions as they reported the maximum and minimum temperatures are showing significant increasing trend over the last three decades. This result could support the finding of [16] who report that both minimum and maximum temperatures have a significant positive trend. The annual rainfall over the study areas showed that a significant decreasing trend (Fig. 2). It is evidence from the Mann Kendall test and Sens's slope estimator test that annual rainfall has a significant negative trend. On the other hand, a statistically significant increasing trend was observed for annual temperature (Fig.3). This suggests that long-term climatic change related to changes in precipitation patterns, rainfall variability, and temperature is most likely to increase the frequency of droughts and floods in Ethiopia. A study conducted by [5] pointed out that, in a highly agrarian community like Ethiopia, where the livelihood of the population and the gross domestic product of the country are almost entirely dependent upon rain-fed agricultural production, analysis of precipitation and temperature patterns has paramount importance to cope with impacts on crop yields, animal breeding, power production and ecosystem management. From the ongoing discussion, trend analysis studies conducted so far in Ethiopia are not conclusive and some are conducted at macro scale; which needs further research.

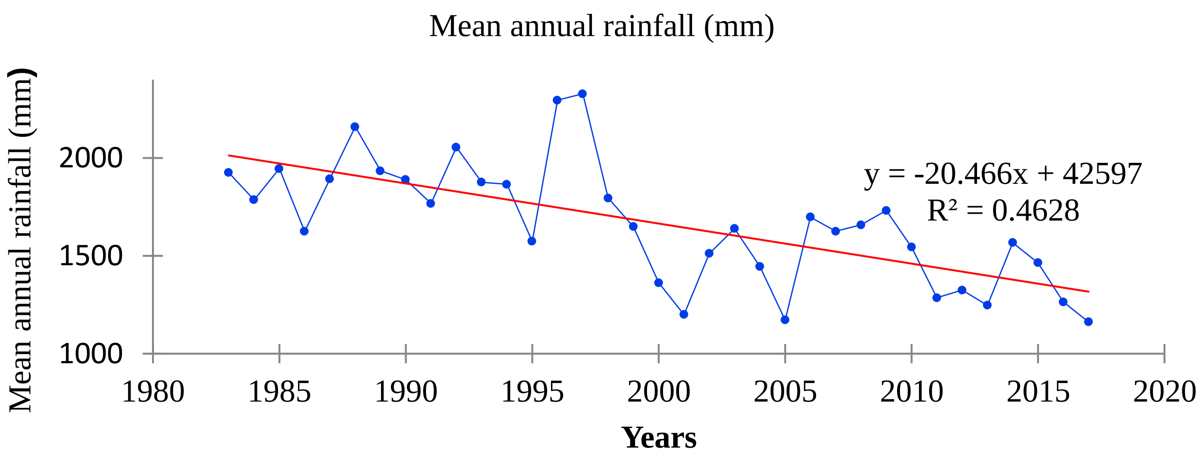

Figure 2: Trends in annual rainfall from 1983-2017 at Ale district

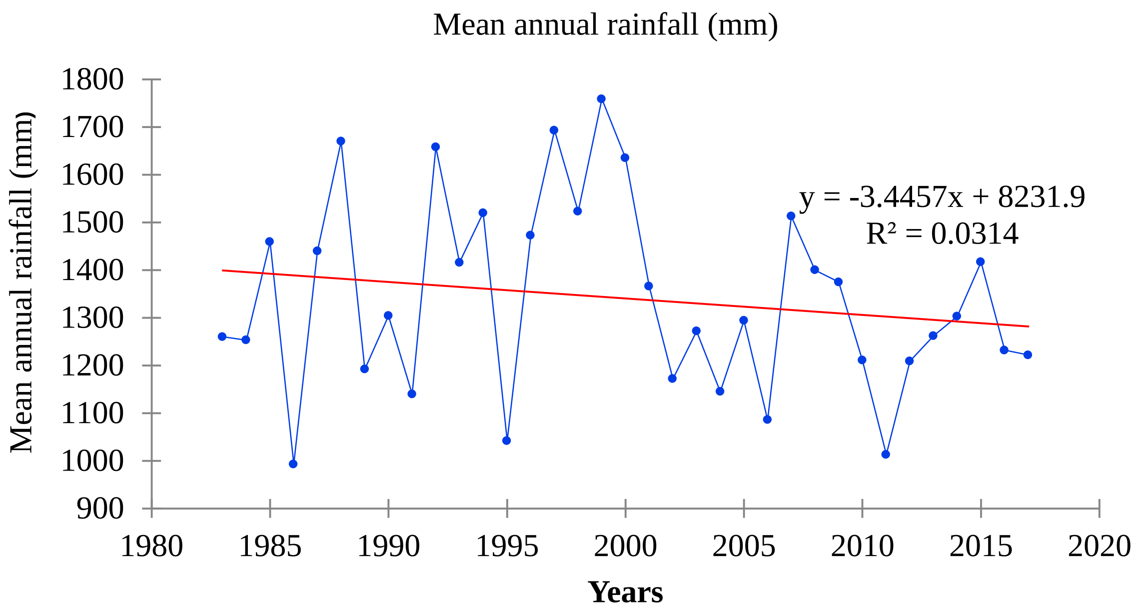

Figure 3: Trends in annual rainfall from 1983-2017 at Bure district

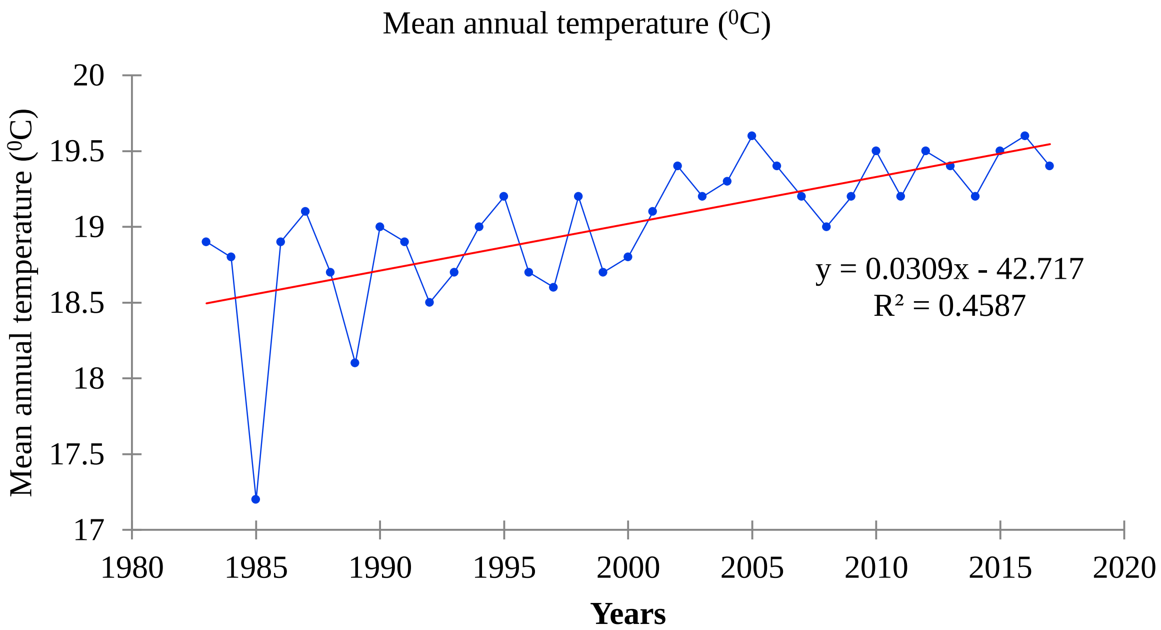

Figure 4: Mean annual temperature trend at Ale district from 1983-2017

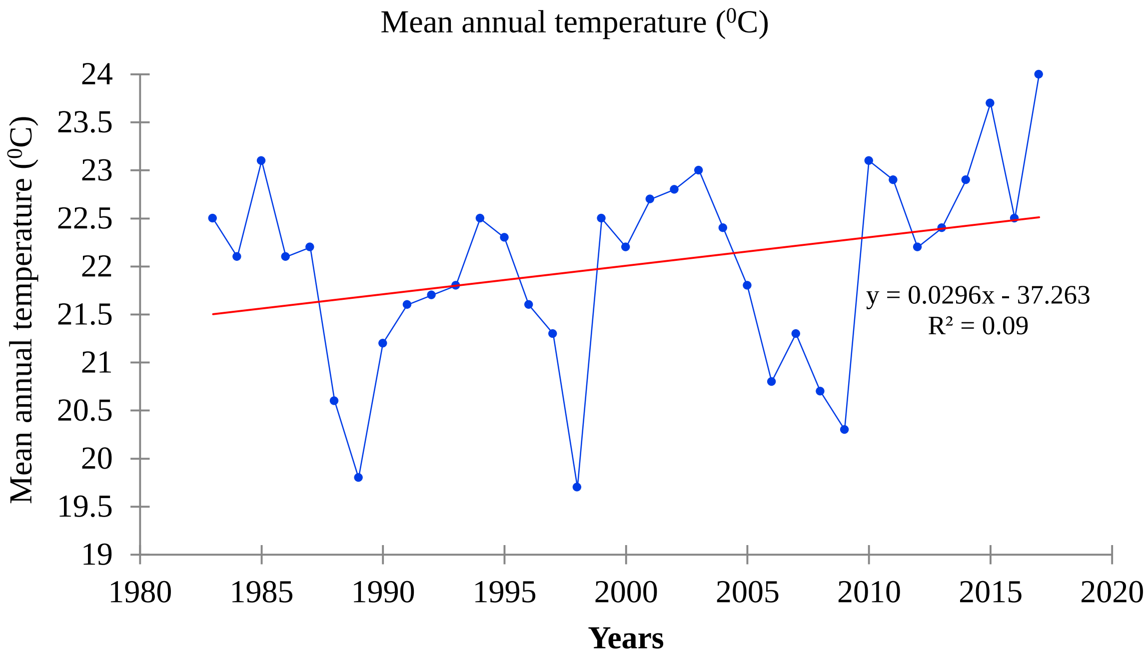

Figure 5: Mean annual temperature trend at Bure district from 1983-2017

Table 3: Results of the trend analysis done on climate

Variable	Mann-kendall's test	P-value	Sen's slope	Mean	SD
Mean Temperature at Ale district	0.573	0.0001*	0.025	19.02	0.47
Mean Temperature at Bure district	0.230	0.004*	0.031	22.01	1.02
Mean annual rainfall at Ale district	-0.123	0.032*	-2.98	1836	120.1
Mean annual rainfall at Bure district	-0.116	0.012*	-3.57	1340.6	199.24

* Significant level at alpha = 0.05

The results of trend analysis are matching with the perceptions farmers about climate variability and change, as the annual rainfall and mean annual temperatures are showing significant decreasing and increasing trends especially during the last half and two decades in the study area. The survey results also showed that farmers perceived the climate change in the past 34 years. In general, most of the farmers felt that temperature had increased over the past two and half decades. The observed temperature data showed a clear signal of general warming trend throughout the study area during the period from 1983 to 2017.

3.3 Farmers' adaptive responses to climate variability and change

The farmers to overcome the challenges of climate variability and climate change on their livelihoods have used different types of adaptation measures. Table 4 shows the different types of adaptive measures implemented by the surveyed households to the experienced climate variability and change in the study area. Soil and water conservation activities are a widely used adaptation strategy as reported by majority of the respondents (73.5%) in the study area. As focus group discussants and key informants, mentioned soil and water conservation activities have been undertaken at household and community levels to adapt to the changing climatic conditions and local environmental change. As one focus group said, 'community level interventions include forestation and reforestation activities and soil and water conservation practices in which a majority of households participated'. This implies that smallholder farmers can adapt to climate variability and change through sustainable land management practices that help to of set the negative impacts at farm level. At the household level, farmers also implement different types of soil and water conservation measures including planting of shade trees and small irrigations.

Table 4: Climate change adaptation strategies practiced by farmers

Adaptation strategies	Percentage of adopters (%)
Changing planting dates	60.4
Crop diversification	54.6
Use of disease and pest resistant crop variety	47.2
Agro forestry practices	62.9
Soil and water conservation practices	73.5
Planting shade tree	62.2
Beekeeping	79.3
Afforestation and reforestation practices	67.3
Small scale irrigation	29.9

Source: Field survey, 2018

As can be seen from Table 4, 64.4% and 62.9% of the respondents implemented changing planting dates and Agro forestry practices in the study area, respectively. Similarly, 79.3% and 62.2% of the respondents respectively used beekeeping and planting shade trees as one of the adaptation strategies to climate change. Key informant interviews and focus group discussions also confirmed the survey findings that farmers take different measures to climate change.

4. Conclusion and policy implications

The study examined the smallholder farmers' perception of climate variability and change and their adaptation strategies in Ale and Bure districts, southwestern Ethiopia. Both qualitative and quantitative information about the smallholder farmers' perception on the climate change and to their specific adaptation strategies. Apart from that, analysis of the observed meteorological parameters was carried out to substantiate whether their perceptions match with the reality. In examining the perceptions, this study confirms that majority of the farmers are aware about climate variability and change. Smallholder farmers perceptions on climate change are clearly supported by metrological data that demonstrated the a statistically significant increasing trends of temperature and decreasing rainfall amount over the past three and half decades. Changing planting dates, crop diversification, planting shade trees, agroforestry systems, soil and water conservation practices were identified as major important adaptation strategies implemented by farmers. Based on the findings we conclude that the government should develop more effective and promote local adaptation strategies to address the adverse impacts of climate variability and change in the study area. Improving farm-level use of multiple climate change adaptation strategies and ore information on climate change adaptation is necessary to enhance and facilitate local adaptation options. Furthermore, in order to overcome the challenges climate change and variability in the study area government needs to support them in promoting the appropriate adaptation measures suitable in location specific area.

Acknowledgement

The authors would like to acknowledge Mettu University, Research Affairs Directorate office for providing fund for conducting this research. The districts of Agricultural and Rural Development and kebele offices, enumerators and farmers also deserve appreciation for their kind cooperation and support during data collection. We also thank the National Meteorological Agency of Ethiopia for providing rainfall and temperature data.

References

[1]. Intergovernmental Panel on Climate Change (2012). Summary for Policymakers. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Alen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 3-21

[2]. Intergovernmental Panel on Climate Change (2014). Climate change synthesis report summary for policymakers. Retrieve from https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf

[3]. Wright, H., Vermeulen, S., Laganda, G., Olupot, M., Ampaire, E., & Jat, M. L. (2014). Farmers, food and climate change: Ensuring community-based adaptation is mainstreamed into agricultural programmes. Climate and Development, 6(4), 318–328.

[4]. Yesuf, M., Falco, D.S., Deressa, T., Ringler, C., & Kohlin, G. (2008). The impact of climate change and adaptation on food production in low-income countries: Evidence from the Nile Basin, Ethiopia, IFPRI

[5]. Alemayehu, A., & Bewket, W. (2017). Local spatiotemporal variability and trends in rainfall and temperature in the central highlands of Ethiopia. Geografiska Annaler: Series A, Physical Geography 99 (2), 85–101.

[6]. Gay, C., Estrada, F., Conde, C., Eakin, H. & Villers, L. (2006). Potential impacts of climate change on

agriculture: a case of study of coffee production in Veracruz, Mexico. Climatic Change 79, 259–288

[7]. Alia, A., & Erenstein, O. (2017). Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan. Climate Risk Management (16) 183–194

[8]. Yunkura, S. (2017). Farmers and policy-makers' perceptions of climate change in Ethiopia. Climate and Development. http://dx.doi.org/10.1080/17565529.2017.1291408

[9]. Deressa, T., Hassan, R., Ringler, C., Alemu, .T., & Yusuf, M. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. Global Environmental Change, 19, 248–255

[10]. Central Statistical Agency of Ethiopia (2013). In: Population Projection of Ethiopia for All Regions at Woreda Level from 2014–2017. Addis Ababa, Ethiopia

[11]. Tadesse, S., Woldetsadik, M., & Senbeta, F. (2016). Impacts of participatory forest management on forest conditions: Evidences from Gebradima Forest, southwest Ethiopia, Journal of Sustainable Forestry, 35(8), 604–622.

[12]. National Meteorological Agency of Ethiopian (2016). Temperature and Rainfall data of Gore meteorological station (Addis Ababa: Unpublished document).

[13]. Kumar, R. (1999). Research Methodology: a step-by-step guide for beginners. SAGE publications Ltd, London

[14]. Birsan, M., Molnar, P., Burlando, P., Pfaundler, M., 2005. Stream flow trends in Switzerland. J. Hydrol. 314, 312–329

[15]. Central Statistical Agency (2016) Agricultural sample survey report for the year 2015/2016 (Report on land use utilization for private peasant holdings, meher season). Vol. 4. Addis Ababa, Ethiopia.

[16] Dhanya, P & Ramachandran, A. (2016). Farmers' perceptions of climate change and the proposed agriculture adaptation strategies in a semi-arid region of south India, Journal of Integrative Environmental Sciences, 13:1, 1-18, DOI: 10.1080/1943815X.2015.1062031

[17]. Bewket, W (2012). Climate change perceptions and adaptive responses of smallholder farmers in central highlands of Ethiopia, International Journal of Environmental Studies, 69:3, 507-523

[18]. Cheung, W.H., Senay, G.B., Sing, A., 2008. Trends and spatial distribution of annual and seasonal rainfall in Ethiopia. Int. J. Climatology, 28, 1723–1734.