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Local perceptions and adaptations to climate change and variability: Evidences from Southern Ethiopia.

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Abstract

Purpose: climate change and variability is emerging as a serious global threat to the nation's future economic prosperity, environmental quality and social wellbeing. The overall aim of this study was to examine climate change and variability vulnerabilities and adaptation responses of local communities in southern Ethiopia. The specific objectives were to explore local peoples' perceptions and adaptation strategies towards climate change and variability and investigate factors influencing these endeavors across cultural and geographical contexts.

Methodology: Four sample study areas were purposively selected for this study. The criteria for selection were presumed representatives of the Southern Ethiopia in terms of the various environmental attributes & presence of long term meteorological records with in the area. Both Qualitative and quantitative primary and secondary data were used in this study. The primary data was collected using questionnaire, focus group discussions, key informant interviews, in-depth case interview and direct observation. Secondary data (time series rainfall and temperature data spanning a period of 1987-2012) were obtained from Ethiopian National Meteorological Agency. Both quantitative and qualitative methods of data analysis were used.

Results: The findings show that the increasing trend of temperature, unpredictable, erratic and decreasing trends of rainfall were perceived by most of the sample respondents. This result was in line with the meteorological records of temperature and rainfall data of most of the meteorological stations. The standardized annual rainfall anomalies showed that more than 50% of the annual rainfall was below the average annual rainfall record in almost all stations which indicated the occurrences of several worst meteorological droughts in various years. The analysis also revealed that age and educational levels were found to have significant influence on the perception and adaptation of climate change & variability. The adaptation strategies used in the area included adjustments in crop and livestock production as well as involving in other income generating options.

Recommendations: The study suggests that more efforts should be geared to improve communities' education and create better institutional setup that enhance resilience, improve and sustain adaptation strategies to climate change & variability.

Key Words: *Climate change, variability, knowledge, Perception, Adaptation*

1.0 INTRODUCTION

Climate change and variability is rapidly emerging as one of the most important issues on the global political and economic agenda and global challenge of our time affecting many areas in the world. Climate change refers to a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer (IPCC, 2007a). Climate variability is variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may result from natural internal processes within the climate system (internal variability) or from variations in natural or anthropogenic external forcing (IPCC, 2001a).

While climate change is global in nature, potential changes and consequences are not expected to be globally uniform; rather, there are dramatic regional differences. In this regard, Africa is one of the most vulnerable continents to climate change and variability in the world due to its economic fortunes is often tied to climate and limited adaptive capacity (IFAD, 2010; IPCC, 2007 & Boko *et al.*, 2007).

Ethiopia, one of the Sub-Saharan countries which is most vulnerable with the least capacity to respond (Amsalu & Adem, 2009).There is also a growing understanding that climate variability and change poses serious challenges to economic development and social progress in Ethiopia. The reason for this is that the economy of the country depends largely on rain-fed agriculture and other natural resources, which is highly sensitive to climate change and variability across time and space. This is aggravated by its high population growth rate; low adaptive capacity; inadequate road infrastructure in droughtprone areas and weak institutional structures. Previous studies have pointed out that Ethiopia has historically experienced a number of major national droughts since 1960's, along with literally dozens of local droughts which affected millions of people and livestock (Derassa, 2010; Reliefweb, 2012). Southern Ethiopia, which is the subject of this study, is not an exceptional. As in many other parts of the country, it suffers a lot from erratic weather patterns such as heat stress, longer dry seasons and unpredictable rainfall (Temesgen *et al*., 2014; Degefu & Bewket, 2014; Bryan *et al*., 2009; Amsalu & Adem, 2009).

1.1 Problem Statement

Despite, Ethiopia is generally considered highly vulnerable to climate change; empirical studies are still limited and patchy in the country so far. Theoretically there is a consensus that better understanding of the local dimensions of vulnerability is essential to develop appropriate adaptation measures (World Bank, 2011). Nevertheless researches on local magnitude in terms of vulnerability and underlying capacity of communities for prioritized action are not satisfactory known. Moreover, preceptions might influence people's attitudes toward climate change as well as their willingness to act and to support mitigation & adaptation policies. Hence, research generated information pertaining to what the public currently know about climate change & variability across agro-ecological zones and across cultural settings is important.

1.2 Objectives of the Study

The overall aim of this study was to examine local peoples' perceptions on climate change and variability and to provide evidence based findings that would contribute to enhancing farmers' capacity to enhance resilience, improve and sustain adaptation strategies to climate change & variability in the area. The specific objectives were to:

I. explore local peoples' perception towards climate change and variability and investigate factors influencing these perceptions across cultural and geographical contexts

II. relate local perceptions on rainfall and temperature extremes with values computed from nearby meteorological station data

III. assess local impacts of climate change and variability induced-hazards on peoples' livelihood and the environment in local peoples' view

IV. identify and document coping strategies developed by local communities on their own context

2.0 LITERATURE REVIEW

2.1 Theoretical framework

Climate change has been documented as one of the most challenging emerging problems facing the world today. Problems related to climate change and variability induced hazards and the vulnerability of exposed communities in terms of livelihoods, infrastructure, ecosystem services and even governance. The vulnerability and exposure of societies and ecological systems to climate-related hazards vary spatially and temporally constantly because of changes in economic, social, demographic, cultural, and institutional and governance circumstances.

Adaptation refers to adjustments to practices, processes and systems to minimize current and/or future adverse effects of climate change and take advantage of available opportunities to maximize benefits (Eriksen *et al*., 2012; IPCC, 2007). Adaptations can either be planned or autonomous with the latter being done without awareness of climate change predictions but based on experience and prevailing conditions (Smithers & Smit, 1997).

The adaptation strategies and actions are influenced by factors such as knowledge about climate change, cultural values, resource endowments, access to appropriate technology, institutions support, policies environment and climate change risk perceptions (Adger *et al.*, 2007).

2.2 Empirical Review

A recent mapping on vulnerability and poverty in Africa put Ethiopia as one of the countries most vulnerable to climate change with the least capacity to respond. In Ethiopia, temperature has been increasing annually at the rate of 0.2°C over the past five decades (Yesuf *et al.*, 2008).

Research evidence conducted at different parts of the country indicates increasing temperature and decreasing rainfall trends. A study which was conducted in North showa (Menz Mama Midir), central highland of Ethiopia (Bewket, 2012) found that all of the respondents (N=90) noticed an increasing trend in temperature and decreasing trend in rainfall. Another study which was conducted by (Bewket & Alemu, 2011) in five sample provinces in two river basins (Abay and Baro-Akobo) of Ethiopia had a similar finding. The majority of respondents perceived an increase in temperature and decrease in annual rainfall. Similarly, a previous study undertaken in the Nile basin of Ethiopia that covered 1000 households also reported that there was an increase in temperature and decrease in annual and seasonal rainfalls (Deressa *et al.*, 2008). A study that was conducted in the southern lowlands of the country (Amsalu and Adem, 2009) also found that the majority of respondents perceived decrease in rainfall and number of rainy days, and perceived increase in mean temperatures. A study that was also conducted in Central Rift valley and Kobo areas of the country found that there was an increasing trend of temperature

and decreasing trend of rainfall (Kassie *et al.,* 2013). Another study which was conducted in Adiha, central Tigray (Mengistu, 2011) also found similar patterns of temperature and rainfall.

The country has suffered by a series of droughts and floods which have had devastating socioeconomic and environmental consequences at different times and scales (Viste et al., 2013; Degefu & Bewket, 2014). As it is depicted in some research reports (e.g. Deressa 2010), though the magnitude varies, almost all parts of Ethiopia have been affected by frequent drought and famine. There is considerable evidence that even future climate change and variability projections are not good news for Ethiopia **(**FDRE, 2011**)**.

3.0 RESEARCH METHODOLOGY

3.1 Description of the study area

The study was conducted in Southern Ethiopia. Except Dido Yabello kebele (found in Borena zone of Oromia National Regional State), all the other three sample kebeles are found in the Southern Nations Nationalities and Peoples Regional state of Ethiopia. Aroresa, Lehayte, Dido Yabello and Buge wanche kebeles are found with a greater proximity to Dilla, Konso, Yabello and Wolayta Sodo meteorological stations respectively (Table 1).

Table 1: Sample meteorological stations

Stations	Latitude	Longitude	Periods of observation
Dilla	6.37002 ^{o} N	38.30006^{o} E	1987-2012
Yabello	4.89223 ^{o} N	38.10024^{o} E	1987-2012
Konso	5.25028 ^{o} N	37.48055^{o} E	1987-2012
Wolayta Sodo	6.81002 ^{o} N	37.73005^{o} E	1987-2012

Topographically, the study kebeles were characterized by diverse landscape features with elevation ranging from 1400 m a.s.l. in Dido Yabello to 1860 m a.s.l. in Buge Wanche Kebele of Sodo Zuria district. Because of the diverse topography, the study kebeles experienced diverse climatic situation that range from arid and semi arid lowlands to warm and humid highlands. The average annual rainfall of sample stations ranges from 550 mm in Yabello to more than1300 mm in Dilla station.

With the exception of Dido Yabello (mainly based on livestock rearing), mixed farming system is the main economic activity in the other study kebeles. The old age indigenous agro forestry system, which is characterized by ever green coffee, fruit and shed trees, is the typical agricultural systems practiced in Aroresa kebele where as mixed crop-livestock system is predominant in Lehayte and Bunge wache kebeles.

3.2. Research Design and approach

Research design explains the framework of the research. In this study, a place-based multiple Case study & exploratory research design were preferred and used. Since, no single research method can capture all dimensions of a complex research problem, this research employed mixed research approaches (that combine qualitative techniques with quantitative ones in order to make them complement each other). Quantitative approaches were employed to quantify trends of meteorological data and data generated from survey questionnaire while qualitative approaches employed to explore perceptions of the local communities. This belief supports the contention that qualitative methods are participatory in nature and seek to understand the reality of the situation from the actors' points of view (Kane, 1995).

3.3. Sample size and sampling procedures

A multi-stage sampling technique was used to select the study sites and sample households heads in the study area. In the first stage, the southern Ethiopia was selected as the overall study site. In the second stage, four districts were selected based on representatives in terms of the various environmental attributes, production systems, weather and climatic conditions and availability of long term meteorological records. In the third stage, four study kebeles, one from each district, (Aroresa, Dido Yabello, Lehayte and Buge wanche), were purposively selected. In the fourth stage, five representative villages were randomly selected from each kebeles and in the sixth and last stage; ten farmers were selected from each village residents by employing a systematic random sampling.

3.4. Data sources, collection and Analysis

3.4.1 Data source and data collection techniques

Data for the study were collected from both primary and secondary sources. Primary data were collected through questionnaire (administered through interview schedule), community level focused group discussions, key informant interviews, in-depth individual case interview and direct observations. Structured questionnaire was used to gather information on socioeconomic characteristics, crop and domestic livestock management, access to weather related information services, past trends and current perception of climate change and variability, impacts of climate change induced risks, adaptation measures undertaken and challenges to adaptation.

Prior to formal survey, a pretesting of the questionnaire was performed to ensure relevance, validity, and reliability. Focus group discussions were used in order to capture information related to historical trends and indigenous adaptive innovations to climate change and variability. Two focus group discussions (with 8-12 participants) were held for each sample kebeles. In the group discussion gender and age breaks were considered. A checklist was used to guide the discussion and to verify and balance information collected by other techniques.

A total of 60 key informant and individual case interviews, (fifteen interviews from each Kebele) were carried out with elders (both men and women), Kebele administrators, religious leaders, successful farmers, and local experts. For ease of recalling of past events, participants were asked based on historical timelines. Most interviews were conducted using local interpreters. Like that of the focus group discussions, checklists were developed to guide key informant interviews. Moreover, transects

walks and Field observations were also employed. Secondary data (26 years rainfall and temperature data) were purchased from Ethiopian Meteorological Service Agency.

3.4.2 Method of data analysis

Both qualitative and quantitative data analysis were used in this study. Descriptive statistical tools such as, mean, standard deviations and coefficient of variation were used to summarize and categorize questionnaire response data. Chi-square and a one-way ANOVA tests were also employed to compare variances and group means respectively. The meteorological data were analyzed by linear regression using Microsoft Excel statistical software to surmise trends in climate variation and their statistical significance. This technique was applied to quantify temperature whereas Long-term annual rainfall changes were examined using the nonparametric Mann–Kendall's test and Sen's slope estimator using MAKESENS Microsoft Excel add-in software developed by the Finnish Meteorological Institute (Salmi *et al.*, 2002). MAKESENS uses the nonparametric Mann–Kendall test, which is most commonly used to analyze trends in rainfall, stream flow and water quality (De Luis et al, 2002; Hamed, 2008; Shahid, 2009).Trend analysis using linear regression assumes normality and homogeneity of variance throughout the series and may be adversely affected by outliers and missing data (De Luis et al, 2002). However, the nonparametric statistics are usually much less affected by the presence of outliers and missing values, and they represent a measure of monotonic dependence whether linear or not (Salmi, 2002). Therefore, the nonparametric Mann– Kendall trend test is robust since trends in climatic series are rarely linear (De Luis et al, 2002). To estimate the true slope of an existing trend (as change per year), the Sen's linear method was used. The standardized rainfall anomalies (SRA) were calculated and graphically presented to evaluate the inter-annual fluctuations of rainfall in the study areas over the period of observation, described in (Agnew and Chappel, 1999) as:

SRA= (Pt-Pm)/σ where: SRA is standardized rainfall anomaly,

Pt is annual rainfall in year t,

Pm is long term mean annual rainfall over a period of observation

σ is standard deviation of annual rainfall over the period of observation.

As indicated in Agnew and Chappel (1999), SRA is helpful to determine the level of drought severity. Accordingly the drought severity classes are extreme drought if (SRA< -1.65), severe drought (-1.65< SRA < -1.28), moderate drought (-1.28 < SRA< -0.84), and no drought (SRA >-0.84). The data were processed and analyzed using computer software packages such as MS Excel and Statistical Package for Social Science (SPSS).

4.0 FINDINGS AND DISCUSSIONS

4.1. Local farmer's Source of information on climate change and variability

The result revealed that 97 percent of the local farmers did not get sufficient and timely information on climate change and variability from the relevant government institutions. The limited information source to the farmers was daily weather forecast through radio. Since most of the farmers do not have radio, they may not get access to the information. The majority of farmers who owns radio pointed out that the information was found to be inadequate and of a very short term remedy. Their expectation is to have medium to long-term weather forecast information. In reality, however, weather predictions usually focused on major towns, and its relevance to many rural communities is insufficient. It was argued that

weather condition is too variable with in short spatial and temporal references. Seasonal weather forecasting may increase the warning time for climatic hazards and it may be used to minimize risk (Murphy, 2001).

A 45 year old female head of household participants in Konso kebele explained her feelings as follows:

> *"We got weather information mainly from development agents, and sometimes from radio. But the information disseminated by the radio was not as such useful for us. Because the radio is forecasting only short term weather conditions. But we need long-term weather conditions and early warning system. These will help us to take preventive actions before the hazard is taking place. The information disseminated by the radio, sometimes, was not concomitant with the weather conditions of our locality. We are living in hostile environment. We ought to have a day to day follow up of the government. We frequently asked the government to get basic infrastructures for which we didn"t get satisfactory answers".*

This indicates that though the people of Konso are well known for their own indigenous terracing and agro forestry practices which have significant contribution to combat desertification and mitigate the effects of drought peoples still perceive the incidence of climate change and variability in their localities.

A 65 old men focus group participants in Dido Yabello kebele on his part elucidated in the following ways:

> *"As you can see, we are pastoralists. The livestock have nothing to graze on and spend the whole day lying on the barren land. They are dying of hunger and disease. The area is not conducive for agricultural activities particularly for crop production as rainfall is not sufficient. You can see, this is the pond water that we use for drinking (the water seems not potable). In drought years we lost many of our assets. We do not get adequate information about the future weather condition of the area from the concerned government sources thereby to adjust ourselves ahead of the disaster".*

All these indicate that local communities need effective and locally-relevant weather related information at the community level. In fact weather stations were installed by the National Meteorological agencies of Ethiopia with the aim of providing climatic and weather related information to the community. However, the weather data from the stations reported distantly to the offices of National Meteorological Agencies at Addis Ababa, and the nearby local community think as if they did not benefit directly from it. Even some members of the community wrongly perceived that the stations are not functional.

4.2. Local Communities' Perceptions of Changes in Temperature and Rainfall

The study results (Fig. 1 and 2) indicate large number of farmers perceived that there was climate Change and variability in the study areas as most of them have been observing increase in temperature and decrease rainfall over the last few years .

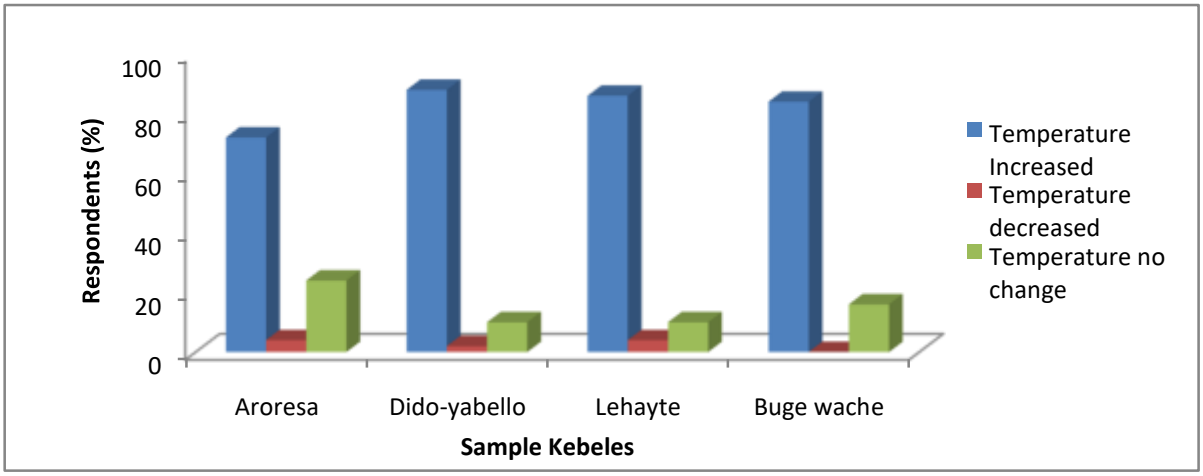


Figure 1: Local communities' perceptions of change in temperature

The result indicated that the respondents from the semi-arid zones (Dido Yabello kebele of Yabello province and Lehayte kebele of Konso special district) were seems most aware of climate change and variability. Indeed, 90 percent of them were aware of the existence of climate change and variability. This was followed by those in the mixed agriculture area of Buge wanche kebele of Sodo zuria province (84percent) and Aroresa kebele of Dilla zuria province (76 percent). Among the respondents who perceived climate variability and change, 72, 88, 86, and 84 percent in Aroresa, Dido Yabello, Lehayte and Buge Wanche kebeles respectively perceived an increase in temperature whereas less than 5 percent of the respondents in the study areas perceived a decrease in temperature. Some of the respondents didn't perceive any change in temperature in the last few years. The implication is that although there is a slight difference the majority of respondents in the study area perceived that there is climate changes and variability in their locality.

On the other hand, the majority of the respondents (82, 82, 72 and 58, percent) in Dido Yabello, Lehayte, Buge Wanche and Aroresa kebeles respectively perceived a decrease in rainfall. Some respondents, (10, 4, 6 and 8 percent) in Dido Yabello, Lehayte, Buge Wanche and Aroresa kebeles perceived untimely rainfall occurrences respectively. It means that the change was not in the total amount of rainfall but in the timing of the rains, rains coming either earlier or later than expected. Few also perceived an increasing trend of rainfall. On the contrary, 24, 8, 10 and 16 percent of the respondents in Aroresa, Dido Yabello, Lehayte and Buge Wanche kebeles respectively didn't notice any change in rainfall pattern.

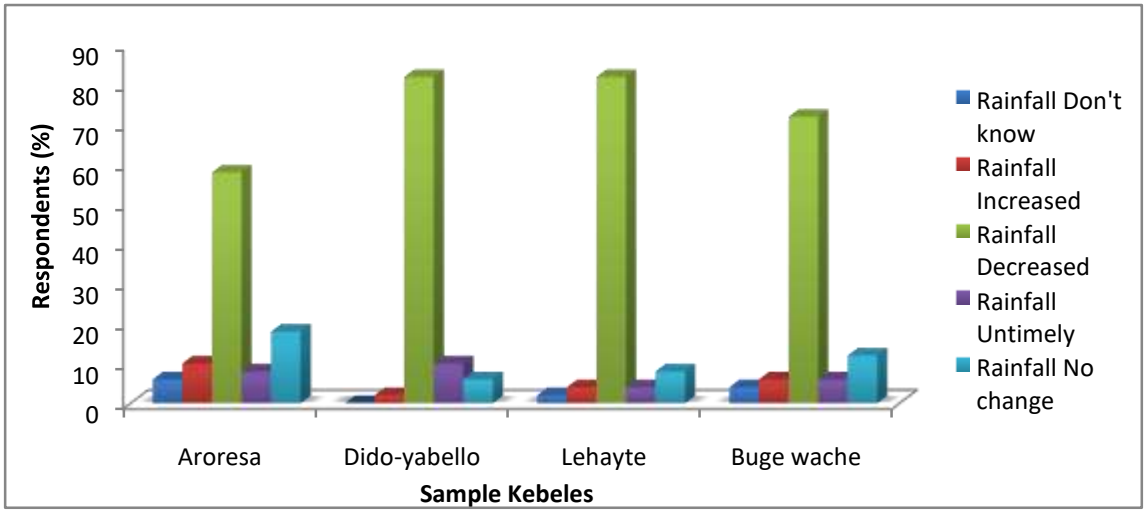


Figure 2: Local communities' perceptions of change in Rainfall

Respondents were asked in the group discussion session about their observations of changes in the local climatic and weather conditions in the past two decades. All of the participants in all study areas unexpectedly shared that they had noticed changes in the local climate i.e, an increase in temperature, decrease in annual total rainfall and frequent drought and flood events in their localities.

FGD participants in Buge Wanche kebele explained:

> *"...when we were young, there were a number of small streams and indigenous trees in our kebele. But recently the rivers and streams were dried up. The temperature is increasing from time to time. The air condition becomes very hot. We used to go far distances to fetch drinking water. The rainfall also becomes erratic and crop production declines from time to time. They further elaborated that rains that used to come regularly during the planting season were becoming more erratic and whenever they came they were often torrential that caused floods and destroying our crops that were ready for harvesting. We are forced to change the type of cropvarities which was previously grown in our Kebele".*

The FGD participants in Lehayte also stated:

> *"Before 20 years, our farmlands were productive. But, today its productivity is progressively declining. This is because, the population pressure is increasing and at the same times the rainfall is becoming irregular and torrential which aggravates soil erosion. The rainfall comes very late, ends early and sometimes fails completely. It does not match with our cropping season. Rivers are dried up. There is also emergence of new species of thorny weeds (not edible for livestock) invading our farmlands which were not observed in our locality so far".* Verification in the field actually provided evident for such of invasive species.

The FGD participants in Dido Yabello similarly confirmed that:

> *"Drought is not a new phenomenon to this area but the frequency used to be 4 or 5 years and now occurred almost every year. The amount and distribution of rain has been reduced and becomes erratic in nature. For example, the main rainy season used to be for 3 months (March*

to May) but since 1984 it has been erratic and decreased to 45 days and 15 to 30 days for the short rainy season (October to December)".

The overall perception is that temperature is increasing from time to time and rainfall is not only decreasing but also characterized by late onset and early cessation. They also added that the rainfall became highly variable and unpredictable and prone to extreme weather conditions. The result agrees with the findings reported by many authors (Bewket, 2012; Bewket, and Alemu, 2011; Mengistu, 2011, Amsalu and Adem, 2009; Deressa et al, 2008).

4.3. Gender disparity in perception to Climate Change and Variability

Independent T-tests were used to judge whether or not there are statistically significant difference between perceptions to climate change and variability among male and female respondents. The result indicated that there was no statistically significant perception differences between men and women to climate change and variability in all the study areas (F= 0.000, P = 0.997).

4.4. Farmers' perception to climate change and variability across the study areas

Similarly, analysis of variance was used to see if there were statistically significant differences in the perception of people to climate change and variability across the different study sites. The result confirmed that there were no statistically significant perception differences among participants to climate change and variability across the study areas (F=1.736, P=0.161). This showed that the participants have similar perception to climate change and variability in all the study areas and they sensed the effects of climate change and variability as their economic activity is highly sensitive to climate stimuli.

4.5. The effect of Age on perception to climate change and variability

The one tailed ANOVA test indicated that there were statistically significant age differences in perceiving climate change and variability in the study areas (F=3.634, P=0.014). Peoples with older age have relatively better experience in the perception of climate change and variability than the youngsters. It was assumed that older people have sufficient long-term experience to provide reliable information on climatic and environmental changes in their locality. This is due to the fact that as the age of the persons increase, their experience in weather conditions in their localities increases and this may help them to improve the probability of practicing different adaptation strategies to the impacts climate change and variability. Research reports indicate that experienced farmers have a higher probability of perceiving climate change as they are exposed to past and present climatic conditions over the longer horizon of their life span. This study is in agreement with (Bewket, 2012; Tazeze *et al.*, 2012).

4.6. Education level and perception of farmers to climate change and variability

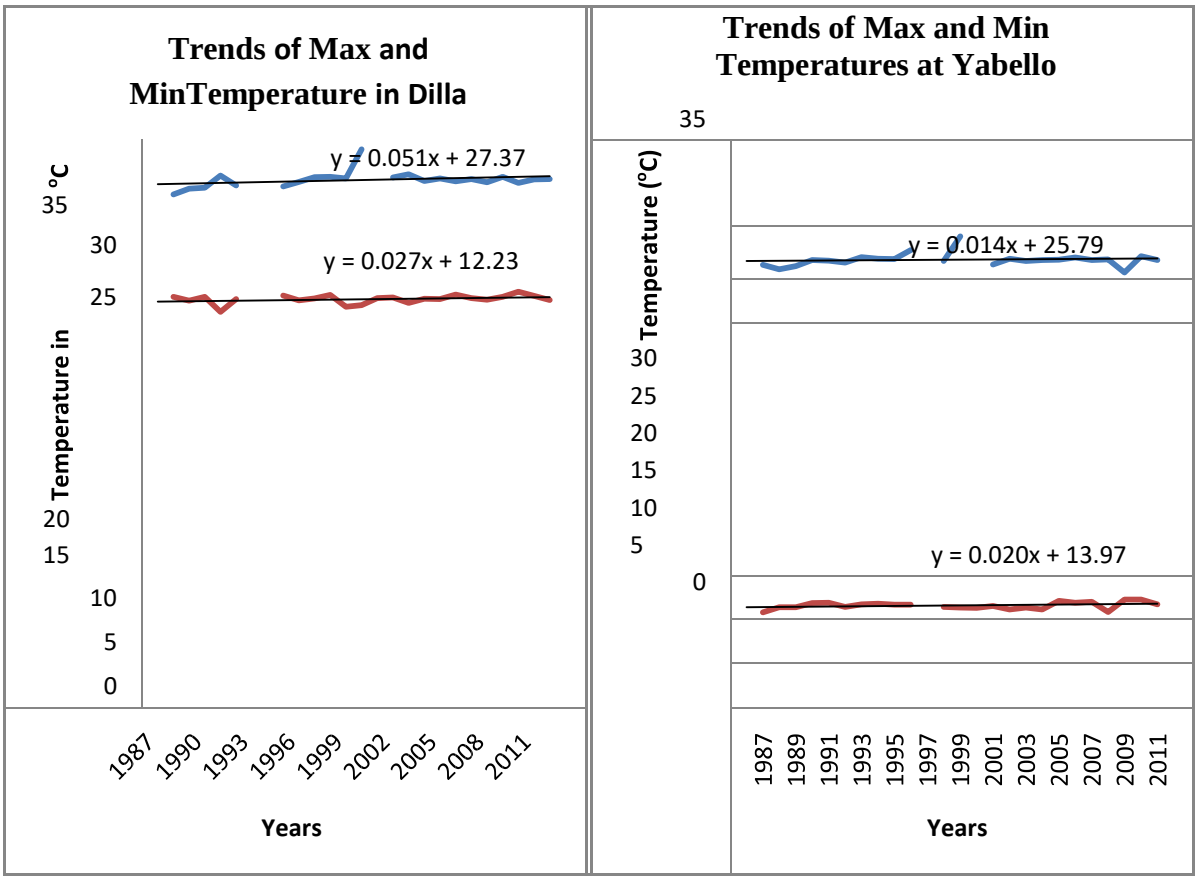
The F-test result reveals that the levels of education is statistically significant in affecting the perception of peoples to climate change and variability (F=8.302, P=0.000). As the test shows the level of education has a very strong link to the perception of climate change and variability. Education level of the household head positively affects awareness of climate change. Access to information on climate change through extension agents or any other sources (formal or informal) creates awareness about the past and current climatic condition and favorable condition for adoption of farming practices that are suitable under climate change. It is apparent that investment on improvement of the ways in which early warning information disseminates and improvement in the education level of household head would yield a better

result in terms of improving the understanding of the prevailing climate change. This result agrees with finding of others (e.g. Tesso *et al.*, 2012).

4.7. Observed rainfall and temperature changes

4.7.1 Temperature Changes

There was an increasing trend in both minimum and maximum temperatures in all of the study areas. For Dilla weather station, the monthly minimum and maximum temperatures has increased by 0.27 and 0.51 ^{0}C per decade, respectively. For Yabello weather station, the monthly minimum and maximum temperatures has increased by 0.2 and 0.14 ^{0}C per decade, respectively. Similarly for Konso weather station, the monthly minimum temperature increased by 0.1 and maximum temperatures increased by 0.21^{0}C per decade.



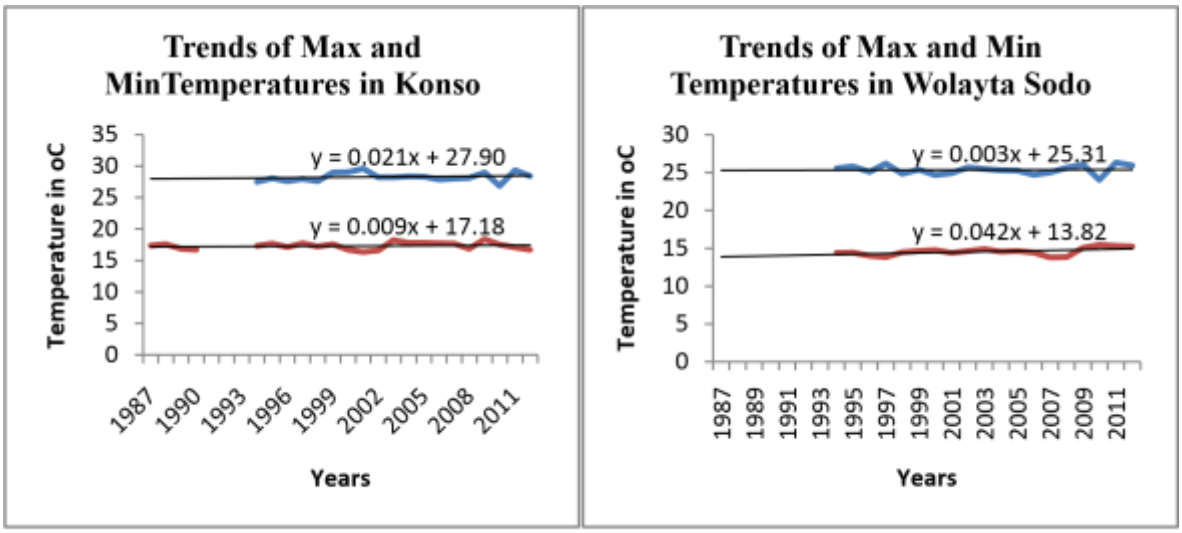


Figure3: Trends of Temperature in Sample Stations

The monthly minimum and maximum temperatures in Wolayta Sodo has increased by 0.42 and 0.03^0C per decade, respectively. As it is depicted in figure 3, the change in minimum temperature was highest in Wolayta Sodo (0.42 ^{0}C per decade) than other study areas. On contrary, the change in maximum temperature was highest in Dilla (0.51 ^{0}C per decade) than the remaining study areas. These figures are higher than the average rate of temperature increment of the country (0.2^0c per decade) (EMA, 2007).

Farmers' perceptions of temperature were compared with climate records provided by the National Meteorological Agency of Ethiopia. Monthly temperature data were analyzed to quantify variability and trends for the period 1987–2012 in four selected meteorological stations i.e., Dilla, Yabello, Konso and Welaita Sodo. The analysis showed that local peoples' perceptions appear to be in line with historical metrological record in the region. It is possible to conclude that peoples were very much aware of the climate condition of their locality. The result of this study, agrees with the studies conducted in the other parts of the country (Amsalu & Adem, 2009; Bewuket, 2012; Kassie *et al*, 2013; Mengistu, 2011).

4.7.2 Rainfall variability and trends

The time series analysis of total annual rainfall was done to reveal the general trends of rainfall amounts over the study areas (Table 3). As the result showed, there was a decreasing trend of rainfall in Yabello and Wolayta sodo with 25.4 and 6.8 mm per decade respectively. On the contrary, increasing trend of rainfall was observed in Dilla and Konso areas with 14 and 11.7 mm per decade respectively. The mean minimum annual rainfall (551.65mm) was observed in Yabello and the mean maximum annual rainfall (1314.77mm) in Dilla.

The mean annual rainfall of Dilla in the study period (1987-2012) was 1314.77mm with mean maximum of 3408.4 mm and the mean minimum of 399 mm. The mean annual rainfall for Yabello, konso and Wolayta sodo was 551.65, 627.27 and 1252.88 mm respectively. There was spatial variation on the mean annual rainfall amount within the study areas.

In relation to the trend of rainfall over the study period, it was noted that in some areas rainfall was increasing and in some others it was decreasing. But the rainfall variability was a common phenomenon in all the study areas. The agro pastoral areas of DidoYabello and Lehayte were highly characterized by rainfall variability. Table 2 shows a summary of the average annual rainfall, Standard deviation, coefficient of variation and trends of rainfall recorded at sample stations.

Table 2: Rainfall Variability and Trends

Station	Mean(mm)	SD	CV (%)	Trends of rainfall (mm/decade) and Mann Kendal test	Sen's estimator (slope)
Dilla	1314.77	530.66	39.5	14	12.94
Yabello	551.65	218.15	38	-25.4 *	-12.97
Konso	627.27	197.51	30.6	11.7	6.545
Wolayta Sodo	1252.88	422.19	33.3	-6.8	-3.533

* indicates significant at 0.05 probability level

As indicated above, the highest mean annual rainfall record for the study period was 1314.77 mm 1972 which was recorded at Dilla station. The second highest mean annual rainfall record was observed at Wolayta Sodo station. With regard to community's experience, most of the respondents (85.5 %) in all the study areas perceived a declining trend of rainfall amount. Their rainfall perception was compared with climate records provided by the National Meteorological Agency of Ethiopia. People's perception of decreasing rainfall was not fully consistent with what was shown in meteorological records. This is due to the fact that farmers' perceptions are not always supported by actual climate data. As the Mann Kendal trend test shows there was no statistically clear trend of rainfall in the study areas under the period of observations.

It can be seen, especially from trends in the Yabello and Welaita Sodo station records, that the area has on the average experienced a long-term declining trend in mean annual rainfall and positive trend in Dilla and Konso stations in the last several decades. The decreasing trend at Yabello was only statistically significant ($P < 0.05$). The discrepancy between the actual rainfall trend and farmers' perception may be because farmers generalize their views based on memories of recent drought years (Kassie et al, 2013). The rainfall records obtained from the National Meteorological Agency of Ethiopia showed increment in some areas and decline in other areas. There was no significant trend of rainfall in most parts of Ethiopia (NMSA, 2007). This result was consistent with a recent study done by (Kebede and Bewket, 2009) that covered southwestern Ethiopia and identified increasing trends in annual rainfall at six out of nine stations studied for the period 1978–2007. The findings also agree with the results of other studies in the country (Amsalu & Adem, 2009; Degefu and Bewket, 2013; Ayalew *et al*, 2012; Bewket & Conway, 2007).

There was high inter-annual rainfall variability in all kebeles of the study site. This rainfall variability was confirmed by both the perception of surveyed people and the meteorological record. Almost all (85%) of the respondents in the four study areas stated that the rainfall has become more erratic and the frequency of drought has increased. The inter-annual rainfall variability was shown by coefficients of

variations (Table 2). The inter-annual rainfall variability was highest (>30%) in all study areas. The rainfall variability varies from the lowest 30.6 percent at Konso to the highest 39.5 percent at Dilla. This high coefficient of variation explained that there was large inter-annual rainfall variability in all stations. In relative terms the inter-annual rainfall variability was higher at the stations characterized by bimodal rainfall regimes and lower at the stations that have relatively high amount with monomodal patterns. Dilla and Yabello are found nearer to South East Ethiopia which are characterized by bimodal rainfall regimes. The analysis of historical records showed that there was high variation of rainfall in the study areas. The coefficients of rainfall variation were highest in all sites of the study area (Table 2).

The standardized annual rainfall anomalies were calculated and graphically presented (Figure 4), to evaluate inter-annual fluctuations of rainfall in the study area over the period of observation. Regarding with the standardized annual rainfall anomaly, more than 50% of the annual rainfall was below the average rainfall record in almost all study areas. In other words, the annual rainfall distribution of all study areas was dominated by negative anomalies. During the driest years, the annual rainfall of Wolayta sodo was 2.23, 1.41, 1.15, and 1.09 times the standard deviations below the 1975-2012 mean rainfall of Wolayta sodo. Similarly during the driest years, the rainfall of Konso was 2.0, 1.5, and 0.9 times the standard deviations below the1988-2012 mean rainfall of Konso.
The rainfall of Konso and Wolayta sodo showed highest negative rainfall anomalies which let us to measure the severity of the meteorological drought. The standardized rainfalls anomalies help determine the frequency and severity of meteorological drought in the study areas.

Based on the calculated standardized rainfall anomaly (Figure 4), there were several meteorological drought periods in Wolayta sodo. 1980, 1983, 1985, 1986, and 2010-2011 were the worst years in Wolayta sodo with moderate, severe, moderate, extreme and moderate drought respectively. These driest years had substantial influence on agricultural production. Similarly in Konso, there were three extreme drought years (1991, 1999, and 2000) and two moderate drought years (1990 and 2010). But in Dilla, only 1991 and 1999 were considered as moderate and extreme drought years respectively. Surprisingly, unlike the expectation, the meteorological drought years were a few in Yabello. The droughts in 1998, 2007 and 2008 were moderate. It was only in 2012 that severe drought was observed in Yabello. There were frequent drought years in Wolayta sodo when it was compared with the other study areas. In contrast, there were some wettest years in the study areas over the period of record. In Welaita Sodo, for example, 1981 was the wettest year. But in recent periods, the wettest year was

observed in Dilla in 2008 and followed by 2009 in Yabello.

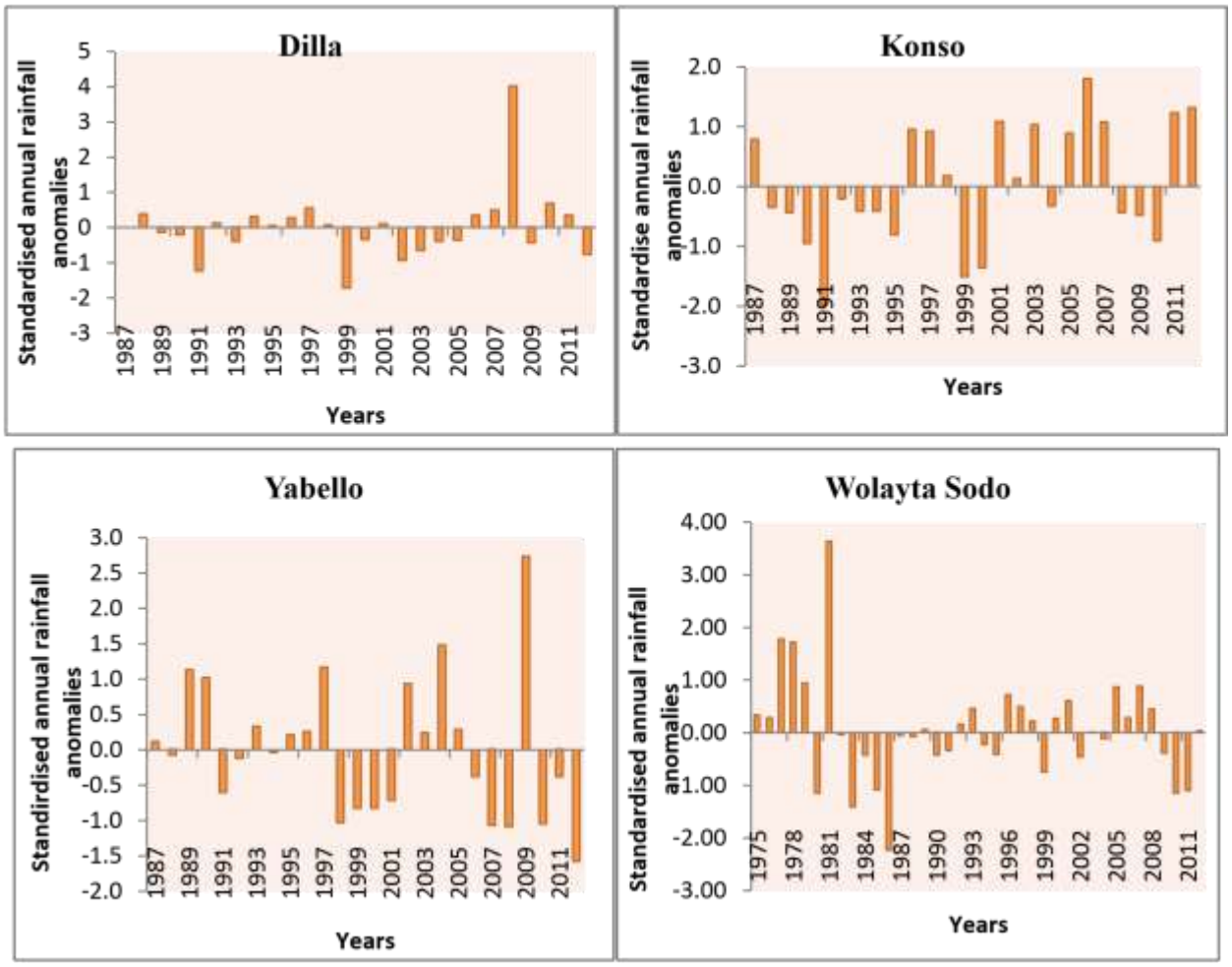


Figure 4: Standardized Annual Rainfall Anomalies in Sample Stations

4.7.3 Perceived causes of climate change and variability

Respondents gave different opinions on the causes of climate change and variability in their respective localities. They attributed it to both natural and anthropogenic causes. A few believed that Poverty is a cause for climate change and variability. This is concomitant to the findings of Nelson and Agbey (2005) which revealed the links between poverty levels and climate change in Ghana. They found that most of the areas with harsh climate conditions have very high incidence of poverty levels. This implies that harsh climate conditions have the tendency to worsen the poverty levels and poverty may in tern impair the quality of the immediate environment for livelihood.

Though some attaches the causes to human actions on the environment, a significant number of respondents (66%) did not provide any scientifically proven explanations about cause of climate change and variability. The majority of respondents perceived supernatural forces as cause of climate change and variability. They associated the cause to breakdown of tradition such as ancestral spirits and community refuses to comply with God's order. They believe that climate change and variability is the

result of annoyance of God against their action. The result of this study was in line with the results of (Amsalu and Adem, 2009) conducted in southern lowlands of Ethiopia.

4.7.4 Perceived impacts of Climate change and variability

The majority of the respondents (above 85%) identified frequent incidence of drought, a change in rainfall distribution, prevalence of unpredictable rainfall pattern, decrease in number of rainy days, increase in warming days, drying of water sources, changes in flowering and fruiting time of plants, appearance and invasion of new plant species in the locality and reduction of some indigenous plants species as some of the major indicators of climate variability and change.

Similarly, farmers in the study area were asked to discuss their perception on the impacts climate variability and change at the time of focus group discussion. Most of them perceived the impacts of climate change and variability in terms of stress as the result of increase in temperature, inadequate/ extreme rainfall and flooding. They also noticed that the weather has changed from the way it was before. Elderly and religious people explains the reduction of productivity and quality of crops and livestock as the result changing climate conditions in almost all study sites.

During the focus group discussions, farmers of Lehayte and Dido Yabello Kebeles, further pointed out that the indigenous plant species that used to grow in the areas have disappeared and have been deteriorated and replaced by wild thorny weeds and shrubs invading exotic types. The new plants species have been easily transported from one area to another by the help of their livestock as well as wind. Field observation proves these recently emerged weed plants that invade most places in the study areas especially in Dido Yabello and Lehayte kebeles. As the respondents explained these weed plant species are resistant even to agricultural chemicals. They shared their fear that in the long run it will invaded productive agricultural and pastures land which in turn will led to crop yield decline and pasture land invasion which may totally exacerbate food insecurity problems.

Climate variability and change affects crop production in many ways. Changes in length of growing period, moisture stress and occurrence of pests and diseases are the major ones (Bewket, 2012). The majority of respondents in almost all study sites revealed that crop yields and livestock products are in critical conditions. Based on their evaluation productivity decreases from what they gained twenty years ago. They also added that the production was declined due to rain shortages and subsequent crop failures. The increased intensity of drought and food insecurity in their localities has been leading to rising trends in poverty levels and dependency on external aid of food and non-food items. The surveyed farmers in Buge Wache reported that root crops became useless due to the insufficient rainfall. The households were forced to change their way to grow non-root crops which will be productive in small amount of rainfall.

Farmers in Aroresa kebele mainly grow enset and coffee in their fields, with other supplements such as soybeans, banana, avocado, and other root plants. Enset is a root crop resembling a banana which is a traditional staple food in south and southwestern Ethiopia. It is high yielding and contributes to household food security. Additionally, its foliage and spongy root systems minimize soil erosion and run-off, which help improve the water holding and soil nutrient capacities of farms. Farmers living in Aroresa kebele were known for their traditional agro-forestry system. Coffee is an important cash crop in this kebele. Farmers reported that the yields of coffee and other crops have been declined from time to time. They attribute this loss to drought, and unusually high rainfalls during the harvest time. A 65

year-old farmer from Aroresa kebele explain his perception on the impact of climate change and variability as follows.

> *"Twenty years ago, I used to grow coffee and the harvest was much higher compared to the present. The rain used to come regularly and consistently, and we were able to plant and harvest on time. But since 1990s the rain has become quite erratic. Sometimes it rains and sometimes it doesn"t. The amount of rainfall was not sufficient as it was before. Coffee growing needs more moisture to get high production. Most of the time long dry spell occurred at the age of coffee maturity and reduced its production. There was also an expected rainfall occurrence during the harvesting period which affects the quality of the coffee. The increasing temperature also worsened the problem of coffee burry disease during extended dry spell and brought financial loss".*

Agro pastoralists especially in Dido Yabello and Lehayte Kebeles encountered enormous losses of livestock due to insufficient amount of food and/ or water. This was common during the dry season, during the time which pastoralists often migrate to cope. Loss of livestock in turn exacerbates vulnerability to subsequent disasters in these areas. Insufficient water availability was one of the major problems mentioned by households living in Dido Yabello and Lehayte Kebeles. They lacked potential sources of underground and surface water. There were no perennial rivers. The seasonal ponds could not hold enough water for residents and their livestock for the entire year. As a result the households were forced to move long distance in search of water for their livestock as well as for the household consumption. They migrated to other areas especially at the time of Bega (dry season) when harsh weather condition starts in the area.

Climate change has direct and indirect impacts on the prevalence and spread of diseases and pests as well. As the respondents explained, prevalence of pests and diseases became a common phenomenon in the study areas. 85.5% of the respondents observed that the areas were affected by the incidence and spread of diseases and pests which are the manifestations of climate variability and change. It brought new human, livestock and crop diseases types that have never been known before in the study areas. Malaria was a common disease in the study areas.

Participants of FGD in Buge Wancho kebele said:

> *"Prevalence and spread of diseases and pests is common in our surrounding. Malaria is a common disease in our kebele. Nowadays it is even going up in areas which were not affected previously. The disease is becoming more severe and critical. There are also livestock diseases which are called „Aba Gorba" (Pecto bacterium carotovorum) and „Aba Senga" (Bacillus anthracis) in this area. They are the main causes for losing our livestock".* This result is similar with the findings of (Amsalu & Adem, 2009).

The participants of FGD in Lehayte explained the consequence of poverty as follows.

> *"As you see we are living on rugged area. We are ploughing our farmlands every year. Our crop production in a year does not uphold our lives for other year. Because of this we practice crop growing without any fallow which facilitates soil erosion and subsequent land degradation. We also cut down indigenous trees and sell them for different purposes. We do all these activities to sustain our lives. These activities have their own contribution to bring climate change and variability".*

4.7.5. Adaptation Responses strategies to climate change and variability

Local and scientific observations showed that the region's climate is changing. Recent evidence includes increasing temperatures and drought frequency, as well as unpredictable rains that fall in shorter but more intense episodes. The magnitude and rate of current climate change, combined with additional environmental, social and political issues, are making many traditional coping strategies ineffective and/or unsustainable, amplifying environmental degradation and food insecurity, and forcing communities to rapidly find new livelihood strategies. In response to the perceived climate variability and change, farm households in the study areas were implementing different types of coping and adaptation strategies such as changing crop variety, adjusting planting and harvesting dates, crop diversification, water harvesting and irrigation, reducing the number of animals, shifting from large animals into small ruminants, selling of livestock and other assets, Selling fire wood and charcoal, depend on remittance, support from the government and NGO, Seasonal migration, to mention but a few.

4.7.5.1 Adaptation strategies in crop production

Local farmers in the study areas practiced different crop management practices as adaptation strategies which include; changing crop variety (81%), adjustment of planting and harvesting dates (77%), crop diversification (74%), planting high value fruit trees (64%), water harvesting and irrigation (69%), planting trees (65%), soil and water conservation practices (82%). Any change in the crop growing period is a great challenge which highly affects farmers' decisions on what and when to do such adaptation measures.

Farmers in the study area were changing the crop variety which they used before twenty years. They were planting early maturing and pest tolerant crop varieties in order to avoid crop failure during shortage of rain and crop diseases respectively. They used to grow not only crops like bean and barely which need lower temperature, but also Godere/Taro/ (***Colocasia esculenta*** (Araceae) and sweet potato (***Ipomoea batatas***) which require high amount of rainfall. Recently they started growing different wheat varieties (ex. Inseno-1(BWPRAW 03/36)) in which higher temperature is suitable for its growth and adenguare (Canavalia Africana) which needs very small quantity of rainfall for maturity and production. They also applied cropping calendar to adjust the planting and harvesting date. Farmers were very much aware of the climate condition of their environment and they diversify the crop types which they grow in their farm. According to the interviewed farmers this method help reduce the climate risk by growing crops in different spaces and times. Improved soil and water conservation technologies are also another adaptation option which has a great role in reducing production risk in Ethiopia. Moisture conservation techniques such as mulching, terracing as well as rain water harvesting were practiced in the study areas to reduce the effects of erratic rainfall distribution. Statistically significant differences were observed among the four study areas in terms of their cropping calendar (X^2= 10.44; P = 0.015), planting of high value fruit trees (X^2= 19.63; P = 0.000), water harvesting and irrigation practices (X^2= 7.94; P = 0.047).

4.7.5.2 Adaptation strategies in livestock production

The majority of respondents in the study areas were engaged in pastoral and mixed farming livelihood systems (livestock and crop production). The changing climate has an adverse effect on the livelihoods of pastoralists and agro-pastoralists. Adaptation measures in the livestock production system has also applied in the study areas such as reducing the number of livestock (84.5%), temporary migration to

wet areas (70%), use of camel, sheep and goats rather than cattle (82.5%), use of improved and productive livestock breeds (85.5%), alternate use of pasture lands (69%).

Two adaptation strategies i.e seasonal migration (X^2=19.66; P = 0.000) and alternate use of pasture lands (X^2= 37.16 ; P = 0.000) have statistically significant differences among the four study areas. This significant difference in these adaptations was observed due to the fact that the pastoralists and agro-pastoralists were mostly applying it.

4.7.5.3 Alternative income generating options

Recently, the frequency of migration has increased in Ethiopia due to the increased negative impacts of climate change and variability on livelihoods (Gray and Mueller, 2012). They indicated that 10 % of the male labor force migrates during severe drought. This implies that developing alternative income generation options for rural areas is very crucial. The surveyed households as well as the focus group discussants explained their alternative income sources in all the study areas. Among the most frequently mentioned options; collection of wild foods, charcoal making and fuel-wood selling, selling of livestock, depending on remittance, engaging in off-farm activities, appealing to safety net program and seeking in cash or kind aid from governmental institutions and/or nongovernmental organizations were the major ones. There was a statistically significant difference in some of the adaptations i.e selling of livestock (X^2=14.11;P=0.003), selling of household assets (X^2=11.2;P=0.011), remittance (X^2=26.2;P=0.000) in the study kebeles.

This difference was observed in that selling of livestock is highly practiced in pastoralists and agropastoralists of Dido Yabello and Lehayte farmers whereas remittance was highest only in Buge Wanche and Dido Yabello kebeles.

4.7.6 Barriers of Adaptation

Farmers have different barriers in order to successfully adapt the changing climate. According to the focus group discussion, unaffordable agricultural inputs, lack of credit facilities, inadequate weather information, and small and fragmented farm plots were considered as a barrier to successfully adapt the ongoing climate change and variability.

Farmers in the FGD expound:

> *"The existing improved crop varieties perform poorly under existing farm conditions if they are not used in combination with other inputs (fertilizer, agro-chemicals, water). When we use the improved seed-fertilizer package, their price is very expensive and we could not afford to buy these inputs. The yield benefit that we get cannot compensate the low output/input price ratio. There are no credit facilities even to buy such expensive agricultural inputs".*

This indicated that farmer's capacity to use the recommended full technology packages was limited. This implies that farmers need low-cost options matching their adaptive capacity, or better access to technologies to cope with the changes and/or adapt to it.

5. 0 Conclusion and recommendations

5.1. Conclusions

The study has tried to describe climate change and variability in the perspective of historical climate data, local perceptions and adaptation strategies from the viewpoint of southern Ethiopia. The statistical

analysis of temperature and rain fall data from records of sample stations reveals that there has been an increasing trend of temperature. But there was no clear trend of rainfall distribution. However, it showed great spatiotemporal variability. Similarly, without significant geographical disparity, a large percent of the farmers surveyed perceived an increase in temperature & variations in rainfall over the past few years. Local communities' perception is congruent with what has been observed by meteorological data. The findings of this research concluded that climate change and variability have been occurred in the study areas like many other regions across the globe.

Despite most households are increasingly conscious of local climate change, there are differing perspectives concerning its causes. Excluding farmers who have no opinion, most farmers in the study area have realized poverty, environmental pressure and deviation from cultural beliefs as the causes of climate variability and change. In this regard, a number of factors found to influence the likelihood of farmers perception about climate change & variability. Increase in level of education and age (experience) increase the possibility that farmers will recognize climate changes and variability. This suggests that perceptions are not based entirely on actual climate conditions and changes but are also influenced by other factors.

Impacts were observed contributing to rising temperatures, reducing crop production, recurrent floods and prolonged droughts, outbreak of diseases and pests, rapid encroachment by invasive species, and emergence of human diseases. Households and communities employ a range of indigenous strategies to cope with the changes and/or adapt to it. However, the strategies are becoming incapable to reduce damages. Some of the strategies such as overgrazing, charcoal making and fuel-wood selling are not only unsustainable but would also cause resource degradation and desertification.

5.2. Recommendations

- The finding of this study reveals that local perceptions of climate change and variability are shaped by factors which may be internal and/or external that include among others, experience, access to information and level of education. The majority of participants misapprehend causes of climate change to purely natural as opposed to anthropogenic. Hence, continued awareness raising campaigns regarding climate change and its harmful effects that incorporates local knowledge is desirable.
- Large number of respondents complained that meteorological information is not adequate and timely. Therefore, In order to adequately promote their adaptation, concerned government institutions should strengthen improved weather forecast and focus on enhancing coping capacities of local communities in addition to emergency responses. This will enable farmers to fully exploit seasonal rainfall distribution to improve and adjust their copping strategies.
- Poverty has been repeatedly raised as an obstacle factor to adapt climate change and variability. Hence, providing support for appropriate agricultural innovations, improve off-farm income earning opportunities and development of alternative livelihood activities are mandatory. Moreover, Strengthen the linkages between research institutions and extension systems at the grass root levels for proper implementation of proven research outputs at the local levels has paramount significance.
- In order to adequately promote their adaptation, farmers must not only be informed about potential adaptation options but also need to get sufficient trainings on available technologies such as integrated watershed management, water harvesting techniques, moisture conservation and

improved agronomic practices, agro-forestry practices, improved crop varieties and animal breeds to mention but a few.

5.3.Area for Future Studies

This study propose for future specific research studies to identifying and quantifying the potential long-term climate change and variability impacts on sectorial basis, different ecosystems and economic sectors.

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