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Research Article

Climate variability, communities' perceptions and land management strategies in Lay Gayint Woreda, Northwest Ethiopia

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Abstract: Climate variability is the fluctuation of climate elements from the normal values making the agrarian communities of Ethiopia the most sensitive social groups to its hazards. The objective of this study is to examine climate variability, local communities' perceptions and land management strategies in Lay Gayint Woreda, Ethiopia. Primary data were collected from 200 randomly selected households settled in varied ecological areas. Metrology data were gathered from Nefas Mewcha Station from 1979 to 2010. Standardized rainfall anomaly index (SRAI), crop diversification index (CDI) and other descriptive statistics were used to analyze the data. The climate and the survey data revealed an increasing temperature, and decreasing and/or erratic rainfall pattern. 2002 and 2008 were extreme and severe dry years, respectively whist 1984 and 1990 received near normal rainfall amount. Over 87 % of the surveyed households perceived an increase in temperature over the last 20 years. The majority of the households are more likely to adopt land management strategies against climate variability. Terraces and check dams construction and planting trees were the major land management strategies of local communities. However, crop diversification index (CDI) was 0.11 indicating very low CD as the cultivated area is dominated by a single crop there. Although the study area receives inefficient rainfall the rugged topography coupled with poor soil conditions have hindered irrigation practices. Integrated watershed management activities and extension services and information dissemination systems should be strengthened and established to provide reliable weather information for farmers given that their livelihood is dependent on it.

Keywords: *adaptation strategies, climate variability, crop diversification, Lay Gayint Woreda*

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Introduction

Climate variability is the fluctuation of climatic elements from the normal or baseline values (Smither and Smit, 1997). Climate is inherently variable in time and space even within a given country. Climate variability is expressed as variations in the mean state and other statistics of the climate on temporal and spatial scales, which may be due to internal processes within the climate system, or anthropogenic external forcing (Intergovernmental panel on climate change/IPCC, 2001; Fussel and Klein, 2005). Seasonal and inter-annual climate variability, including extreme weather events forms an important component of a system's exposure to environmental stimuli (Fussel and Klein, 2005; Ericksen et al., 2007). Climate change will largely affect existing climate variability, including the frequency, intensity, and location of harmful weather events. Onset, duration, and distribution of rains as well as increasing unpredictability of extreme weather events are manifestations of climate variability (Fussel and Klein, 2005; Ericksen et al., 2007). Some inter-seasonal variability is well understood, but much of the variation over long years is poorly understood and largely unpredictable. Thus, decisions on climate-sensitive sectors or activities are usually carried out under uncertainty or risk (Smithers and Smit, 1997).

Agrarian communities are the most sensitive social groups to climate variability due to the fact that climate change affects the two most important direct agricultural production inputs such as rainfall and temperature (Philip et al., 2014). Indeed, the impact of climate change together with other deriving forces poses risks to the nations' food security status (IPCC, 2014). These impacts are deepening the problems of vulnerable smallholder farmers to poverty in the developing countries though they produce 70 % of the world's food needs (Campbell and Thornton, 2014; FAO, 2013). Agricultural productivity remained stagnant and low in smallholder production systems over the last few decades (FAO, 2015). In some cases productivity has already started to decline due to changing rainfall patterns, increasing temperature and frequency of droughts, floods and other extreme weather events (Lipper et al., 2014).

Although agriculture is the cornerstone of the economy and the main source of livelihood in many developing countries severe natural resources degradation, high dependence on rain-fed agriculture, inadequate infrastructure, low levels of technology, and weak governance have led to low level of adaptive capacity to the impacts of climate-related hazards (Slingo et al., 2005). There is a strong link between climate and East African countries' livelihood. Agriculture contributes 40% of the region's gross domestic product (GDP) and provides a living for 80% of the population there (International Food Policy Research Institute/IFPRI, 2004). However, East Africa's heavy dependence on rain-fed agriculture has made rural livelihoods and food security situations highly vulnerable to climate variability (IPCC, 2001). Due to increasing temperature and decreasing precipitation in the region, many areas are being negatively affected.

As part of East African counties, the economy of Ethiopia is heavily dependent on agriculture, contributing about 45% to the GDP, 60% to food security, and 90% to the export revenue and 85 % to generate employment for the work force. About 90% of the total agricultural production is being contributed by small-scale producers. However, the sector is more sensitive to climate variability and frequent droughts causing massive food shortage (Ethiopian Institute of Agricultural Research/EIAR, 2005). Climate change increases the likely happenings of environmental hazards thereby affecting communities' livelihoods and ecosystem health in Ethiopia. This situation exacerbates poverty, damage to infrastructure, social insecurity, and threatens development efforts for many of the decades (Woldeamlak, 2009) and will continue to undermine the overall economic and social development in the future (Aklilu and Alebachew, 2009). In fact, most people of the country live in a period of rapid and dramatic ecological and land-use changes.

Climate change-induced droughts, floods, epidemics and the resultant famines are very common events in the country (Dereje and Tamiru, 2009). Frequent meteorological drought-induced crop damage, famine and disease outbreak have claimed the lives of millions of people and animals in the northern, southern and south-eastern dry-land regions of Ethiopia. Major flood hazards occurred in 1988, 1993, 1994, 1995, 1996 and 2006 have claimed many lives and property in different parts of the country. For instance, the 2006 catastrophic flood have killed more than 650 people, displaced more than 35,000 people and destructed huge infrastructure in Dire Dawa, South Omo and West Shewa (NMSA, 2007).

In recognition of these facts, adaptation to climate change has received increasing attention in the scientific and policy debates together with mitigation (UNFCCC, 2006). The rational is that the degree of adaptation will determine many of the effects of climate change on agriculture though adaptation itself will be determined by farming types (rain-fed or irrigated), income levels and market structure (Parry et al., 2005). Adaptation helps farmers to produce food, generate income and achieve livelihood security objectives in the dynamics of climate and socio-economic conditions (Khan and Short, 2001). Different adaptation strategies are being suggested to overcome the challenges of climate change in different spatial scales. Yet, such strategies are not only expensive but can also have many undesired outcomes (Green Forum, 2008). As climate extreme events are expected to increase in frequency and intensity (IPCC 2001) the current coping strategies may not be sufficient in the future. This needs more work as adaptation is really dynamic and continuous process (Intergovernmental Climate Prediction and Applications Centre/ICPAC, 2006).

In many African countries, including Ethiopia, a range of factors may undermine communities' ability to adapt to climate change (Boko et al., 2007). Knowledge of the factors would assist in targeting intervention windows towards effective adaptation strategies to reduce the harmful impacts of climate extremes. Despite the importance of perceptions and adaptation to climate variability, a very few studies, for example, Deressa et al. (2006); Yesuf et al. (2008) and Woldeamlak (2009) have examined farmers perceptions and adaptation to the impact of climate variability on crop production in the context of Ethiopia. Even these few studies were carried out at the macro-level with little micro-level specificity. Unless, the micro-level community understand the effect of climate variability and/or climate change, it would be hard to convince and motivate local people to undertake adaptation actions. The communities are using different land management strategies to reduce the adverse impacts of climate variability based on their local knowledge and persistent practices. Adaptations assessments should be conducted with the aim of identifying appropriate options and understanding the local effects of recent climate trends on crop yields and food security status of the study area. Therefore, this study was conducted to assess the current status of climate variability, local communities' perceptions to climate variability and land management strategies in Lay Gayint woreda, South Gondar zone of Amhara Region, Ethiopia.

Study Area

Lay Gayint woreda is located in South Gondar Zone of Amhara Region, Ethiopia. Geographically, South Gondar Administrative Zone is located between 11° 02' -12° 33' N latitude and 37° 25' - 38° 43'E longitudes. The zone is bordered in the south by East Gojjam, in the south-west by West Gojjam and Bahir Dar, in the west by Lake Tana, in the north by North Gondar, in the north-east by Wag Hemra, in the east by North Wollo, and in the south-east by South Wollo; the Abbay River separates the zone from East and West Gojjam administrative Zones (Lay Gayint Woreda Office of Agriculture/OoA, 2012).

The climate of the administrative zone is more influenced by altitude. Based on the simplified agro-climatic classification of Ethiopia, it lies within four agro climatic zones. Alpine and tropical zones account for 2.5% and 16% respectively whereas sub tropical and temperate climate zones account for 27% and 54% of the administrative zone respectively. The zone has bimodal rainfall pattern, summer (June to August) is the main rainy season with its peak in July and the short rainy season from February to April. Rainfall varies from 900 mm to1599 mm with the average annual rainfall of 1300 mm. The average temperature is 17°C (LGWADO, 2012). More than 85% of the farming households engage in mixed farming systems and more than 93% of them plough their land using traditional farming technology (LGWADO, 2014). This has made the communities more vulnerable to the impact of climate variability.

Lay Gayint is one of the food insecure woredas of Amhara National Regional State. The Woreda covers an area of 1,548.56km^2 and sub-divided into 29 rural and two urban Kebeles (the lowest administrative unit of Ethiopia). It is bordered in the North by Ebnat and Bugna, in the south by Tach Gayint and Simada, in the west by Estie and Farta Woredas and in the East by Mekiet Woreda of North Wollo Zone. The absolute location of the Woreda is 11°32′- 12° 16′ N Latitude to 38° 12′- 38° 20'E Longitude (see Figure 1). The administrative center is Nefas Mewcha; it is located on the way from Woreta to Woldia high way which is 226 Kms away from Gondar city and 175 kms away from the regional capital city, Bahir Dar (LGWADO, 2014).

The topography of the woreda is dominated by chain of mountains (50 %), hills and valleys (5 %) extending from Tekeze Gorge (1494 meter) to Guna Mountain Summit having the highest elevation of 3991 meter above sea level (masl). The flat terrain constitutes only 10 % of the total area. The woreda is divided into four elevation and temperature based agro-ecological zones, namely: lowland/*kolla* (12.5%), midland/*woyna-dega*) (39.42%), highland/*dega* (45.39%), and alpine/*wurch* (2.71%). Most of the rural population settled in the highlands and plateau areas. The main soil types are brown (55 %), red (15 %), black (15 %), grey (10 %) and other soil type (5 %) (LGWADO, 2011). The annual mean minimum and maximum temperatures range from 8^0 C to 29^0 C respectively. The long-term average rainfall is characterized by high variability and uncertainty. Deforestation, overgrazing and lack of proper soil and water conservation measures have contributed to the prevalence of drought in the woreda. The main rainy season (*Meher*) occurs between June and September and the small rainy season *(Belg)* occurs between March and May. In most cases, the woreda's crop production depends on main rainy season (LWADO, 2010).

The woreda has a total population size of 254,130 (128,427 men and 125,703 women), of which 228,534 (89.14%) were rural and 27,596 (10.86%) were urban dwellers (CSA, 2007). The total area of the woreda is about 154,866 hectares with a crude population density of 157 persons per square kilo meter. The area has very steep valley and incised stream channels with slopes of 0.1% to 38.23% (see Figure 2).

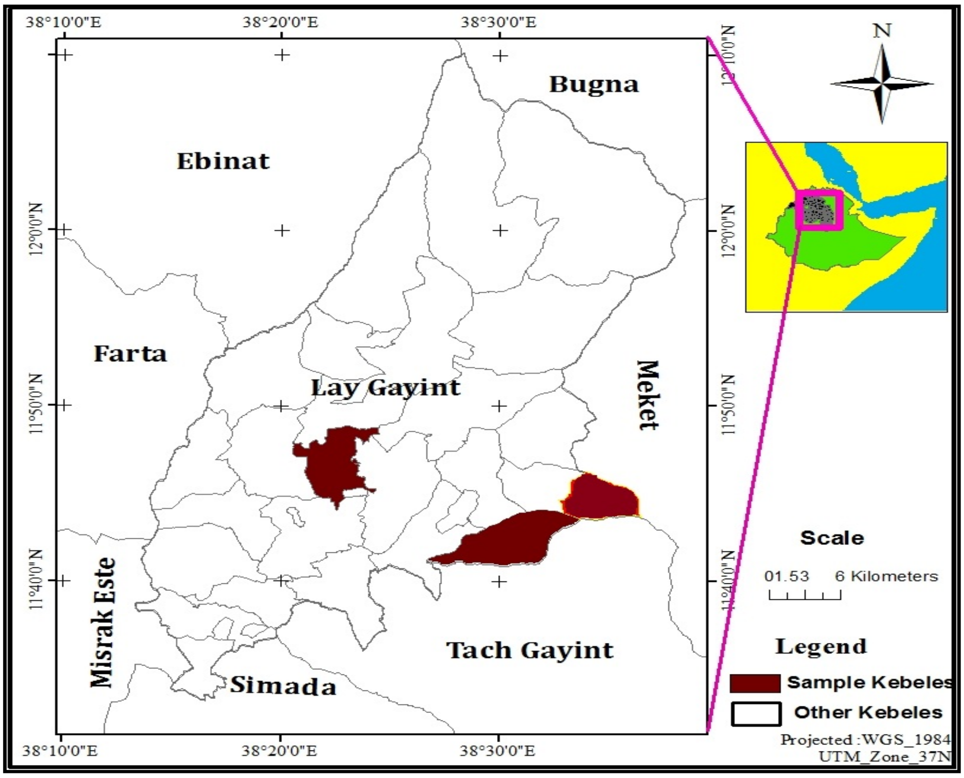

Figure 1. Location map of the study area [Computed based on Ethio- GIS database]

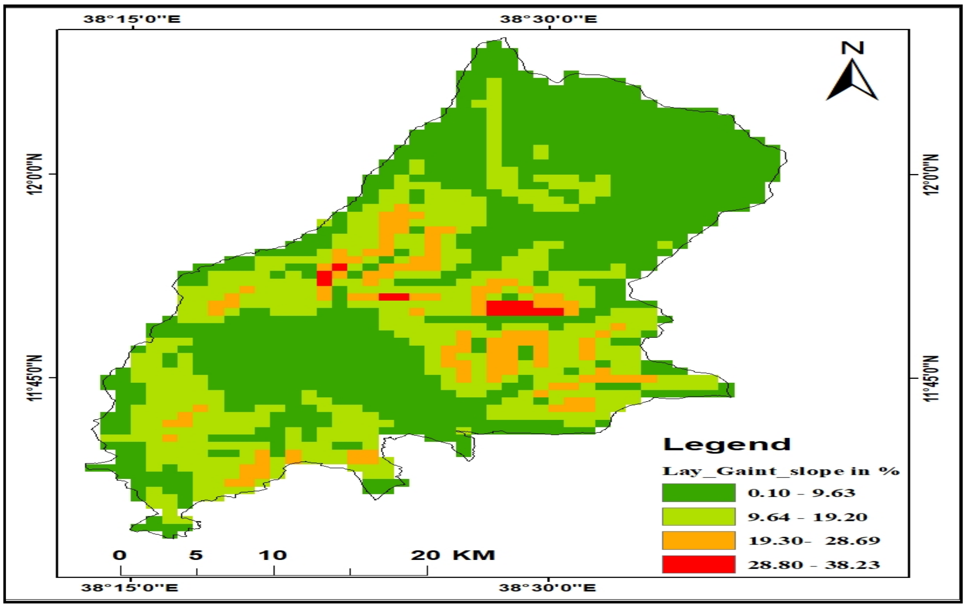

Figure 2. Lay Gayint woreda by slope classification

Figure 2 demonstrates that the slope angle of the woreda ranges from 0.1 % (least sensitive) to nearly 38.23 % (more sensitive) to severe land degradation, land slide, and soil erosion in the rainy season and mass movement in the dry seasons. The major land use pattern comprises cultivable land (44.32%), grazing land (14.31%), forest/bush land (5.26%), water body (2.38%) infrastructure and settlement (5.92%), and unproductive land (28.44%) (Refer to Table 1).

Table 1. Distribution of land use types in Lay Gayint woreda

Land use type	Hectare	%
Cultivated land (annual crops)	68649	44.32
Grazing land	22160	14.308
Bush and Shrubs	8150	5.26
Water body	3665	2.36
Uncultivated land	44041	28.438
Infrastructure, settlement and others	8201	5.29
Total	154,866	100.0

Source: FEDP, 2010

Agriculture (crop and livestock production) is the dominant economic activity in the study area. Crop production is mostly rain-fed, except in very few areas where vegetables are cultivated using traditional small scale irrigation. Both long and short cycle crops are cultivated in *Meher* and *Belg* rainy seasons. The most commonly produced crops are wheat, *teff*, maize, sorghum, barely, cheek pea, beans and oil crops. Livestock have great contribution to the households' income and food security enhancement. The agricultural activity is not productive due to frequent occurrence of natural calamities which deteriorate land resources and increase soil erosion and gullies expansion. Rapid population growth has resulted in shrinking of land sizes. Land degradation, deforestation, moisture stress, water resource depletions, lose of soil fertility and recurrent drought, landslide, crop pests/disease, livestock diseases and weeds together with cultural and attitudinal crisis are among the major problems leading the woreda to be one of the food insecure areas of Amhara Region (LGWADO, 2011). Currently, there is one main asphalt road stretching from Woreta to Woldiya crossing Nefasmewcha town. There are also feeder roads that connect kebele administrations together. There is electricity supply and mobile telephone services for urban and some rural dwellers. The woreda has 2 health centers and 32 health stations with the health service coverage of 84% (LGWADO, 2010). Amhara Credit and Saving Institution (ACSI) is the dominant finance center in the woreda. The studied woreda run extension services by introducing improved technologies, increasing agricultural inputs and providing technical advices to the farmers in order to increase agricultural productivity. To meet this objective, different extension packages have been practiced by development agents (DAs) who are working with the rural farmers (LGWADO, 2010).

Materials and Methods

Sampling methods and procedures

Lay Gayint woreda has 29 rural kebeles found in different agro-ecological areas. The authors used stratified, simple random and systematic sampling techniques. The kebeles were stratified into three categories with respect to their agro-ecological zone (*dega, woyna-dega and kolla*). For the study, three kebeles were selected from each agro-ecological zone using simple random sampling technique. These were Moseb Terara (highland), Argeberas (midland) and Menteleho (lowland). To determine the sample size of each kebele administration (KA), the statistical formula was adapted from Israel (1992) and then by using systematic random sampling technique, sample household heads were drawn from each KA. A total of 200 sample households (70 from Moseb terara, 78 from Argeberas and 52 from Menteleho) were participated in this study. The registered sample populations were obtained from local development agents (DAs) of the respective kebele administrations. One DA interviewee from each kebele, three extension officers and two agricultural experts of the woreda Agriculture Office, were included in the data collection process using purposive sampling method. Moreover, two non-governmental organizations such as Organization for Development of Amhara (ORDA) and Food for the Hungry International (FHI) Ethiopia were also participated in providing the necessary information.

Data collection

In order to examine climate variability, local communities' perceptions and adaptation strategies of local communities in Lay Gayint woreda, both secondary and primary data were used in this study. The 32 years meteorology data (rainfall and temperature) were gathered from Nefas Mewcha Station for the period 1979 to 2010. In addition, land-use and population data were gathered from woreda Office of Agriculture. Other published and unpublished literatures were also consulted in the whole process of the research. The most important instruments used to generate relevant primary data were household survey, field observation and interview. The primary data collection methods covered issues about perceptions of farmers on climate variability and its effects on crop production as well as local communities' adaptation strategies used to mitigate the adverse effects of climate change. Each of the primary data collection instruments are discussed in the sub-sections to come.

Household survey: in this study the household survey was one of the main data collection techniques from the sample households regarding perceptions of climate variability and land management strategies used to mitigate the negative impact of climate variability on land and other resources. The survey questions were organized into close-ended anchored with open-ended forms categorized as basic personal information, perception on climate variability, and land management strategies. The survey questions were prepared in English and translated in to Amharic (local language) and again encoded into English during data processing and analysis. To maintain the validity and reliability of the survey data the questions were thoroughly reviewed by experts in the area. To assess whether the instruments were appropriate to the study, the pretest of questionnaires to 10 households from the three agro-ecological zones were done. Households who participated in the pretest were not involved in the actual survey. After pretesting, vague words were rephrased, inappropriate questions were replaced and deleted. The authors trained data collectors concerning the survey techniques and confidentiality issues. After the training, the data collectors acquired practical experience while the author made a face-to-face interview in the actual data collection in the field. The data were collected by the trained data collectors under the close supervision of the authors in the period of February to March 2013.

Key informant interviews: For the sake of in depth understanding of historical trend of rainfall variability, some impacts of climate variability on crop production and remembered climate risks in the study area, in-depth interview was conducted with elders, Kebele administrators, religious leaders, women, model farmers and local experts. The participants were carefully selected in consultation with woreda and kebele level agriculture officials and data collectors. In this regard, checklists were developed to guide key informant interviews.

Field observation: Overall information on livelihood settings and topographic features of the study area was captured through field observation. Observation focused on crop farms, land use pattern, biophysical characteristics and land management strategies as adaptation mechanisms used at household and community level. It was carried out to cross check the information gathered questionnaire survey, group discussion and interview.

Data analysis

The collected data and were analyzed using quantitative and qualitative analytical techniques. The quantitative data were analyzed using standardized rainfall anomaly index (SRAI), crop diversification index (CDI) and descriptive statistics (mean and percentage). Temperature and rainfall conditions were briefly analyzed based on historical meteorological data.

Standardized rainfall anomaly index (SRAI): The patterns of drought over a range of time scales were analyzed by the Standardized rainfall anomaly Index (SRAI).The SRAI is of course used as a tool to identify and assess frequency and severity of drought events under climate change in many countries (McKee et al., 1993). It is used to determine periods of anomalously dry and wet events (World Meteorological Organization/WMO, 2012). According to Christos et al. (2011), drought is the state of adverse and wide spread hydrological, environmental, social and economic impacts due to less than anticipated water quantities. The primary cause of any drought is precipitation deficiency. Specifically, the timing, distribution, and intensity of this deficiency are related to the existing water storage, demand, and use (Christos et al., 2011).

The probability distribution function is determined from the long-term record by fitting a function to the data. The SRAI which is developed by McKee et al. (1993) is expressed for each time scale as:

$$\text{SRAI} = \frac{\text{P} - \overline{\text{Pm}}}{\sigma} \quad [1]$$

Where: SRAI refers to rainfall anomaly (irregularity and precipitation deficit) over the years, P, is the observed rainfall in the year (1979-2010), $\overline{Pm}$, refers the mean annual rainfall over the years (1979-2010) and σ, refers the standard deviation of rainfall over the year.

Drought is a natural hazard measured by shortage of precipitation that threats the environment and overall development efforts of specific places through creating water scarcity. Therefore, analysis of drought duration, magnitude and severity is highly demanded. McKee et al.(1993) defined the criteria for a "drought event" for any of the time steps and classified the standardized rainfall anomaly index (SRAI) to define various drought magnitude and intensities (see Table 2). Positive SRAI values indicate the presence of greater than the normal precipitation, while negative values of the SRAI designate below normal precipitation amount. The trends of variability in rainfall and temperature and other household survey data were demonstrated by graphs and charts. The main advantage of this drought analysis technique is its simplicity and temporal flexibility. It will be developed based on the probability distribution of precipitation and calculated by fitting a long-term precipitation record for a given station (Khan and Short, 2001). The SRAI is mostly used by drought planners. Calculating SRAI for a specific time period at any location requires a long-term monthly precipitation database with 30 years or more.

Table 2. Standardized Precipitation Index (SPI) categories

SPI values	Intensity category
2.0+	extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
-0.99 to +0.99	Normal
-1.0 to -1.49	Moderately dry
-1.50 to -1.99	severely dry
-2 or less	Extremely dry

Source: McKee *et al*.(1993);WMO(2012)

Crop Diversification Index (CDI) was considered to measure adaptive capacity of rural households based on the area of farmland they owned in hectare under each crop, as it was used by Golam and Gopal (2003);

CDI =1/ ((Pa + Pb + Pc +_ _ _+Pn)/Nc [])

Where:

CDI	=	Crop diversification index
Pa	=	proportion of sown area under crop a
Pb	=	proportion of sown area under crop b
Pc	=	proportion of sown area under crop c
Pn	=	proportion of sown area under crop n
Nc	=	number of crops

If the total cultivated land in the study area is devoted wholly with one crop, the index value will be zero (0) and if it is evenly distributed among all crops (i.e., maximum diversification) the index value approaches one (1).

The qualitative data analysis method was used to interpret and discuss the information obtained through FGDs, in-depth interview and field observations. The collected information was converted into word processing documents. The author had taken some interviews and observational notes transcribed (that, is converting interview, discussion and field notes into text data and then translated from local language (Amharic) to English for answering the 'why' and 'how' questions on local communities' perception and adaptation to climate change.

Results and Discussions

This section presents about the results and discussion of the study. An attempt was made to analyze and present communities' perceptions of climate variability, trends of rainfall and temperature based on the meteorology data and land management strategies as adaptation options based on the data obtained from household survey, key-informant interviews and field observation. The results are presented in the sections to come.

Socio-demographic characteristics of respondents

Population size and characteristics have direct implications on the supply and demand conditions of basic human necessities such as food, shelter, cloth, health and education. The necessities in turn, influence the use of improved technologies and farming practices of rural communities directly or indirectly. In this study, 200 rural households participated with a response rate of 96.9%. The survey result indicates that the majority of respondents, 74.3% in MosebTerara, 65.4% in Argeberas and 71.2% in Menteleho were male-headed while 25.7% in Moseb Terara, 34.6% in Argeberas and 28.8% in Menteleho were female-headed household heads (see Figure 3).

Age captures farming experience of the rural community members. Through experience, farmers perceive and understand the problem of climate variability and/or change and the use of different adaptation strategies to reduce the effects of climate variability and associated risks. Therefore, the age structures of the surveyed households were examined in this study and presented in See Figure 4. It is clear from Figure 4 that 12 % of the respondents were aged 18-27 years, 26% of them were aged 28 - 37 years, and 21% of them found within 48-57 years of age. High percentages (29%) of the respondents were aged 38 - 47 years. The rest 9.5% and 2.5% of them belonged to 58 - 67 and above 67 years of age. People with over 65 years of age often have become a burden to the family as most of them usually become weaker and have health complication with increase in age. Thus, the productive family members could not be able to enhance productivity which could further increase households' likelihoods vulnerability to climate variability and other extreme weather events. Regarding marital status 75.5% of the surveyed households were married, 12.5% were divorced and 6.0% were equally single and widowed. This result is similar to Soyebo's et al. (2005) findings as cited in Mesfin et al. (2011) which state that agriculture is very much practiced by married people to make ends meet and cater for their children. This in turn, confirms the reality of the rural population that almost all farmers are taking the responsibility of farming activities after they married. Figure 5 demonstrates the distribution of surveyed households by educational status. The Figure indicates that 68 % of the respondents did not attend any formal education when this value is disaggregated 39.5% of them were totally illiterate with no education of any kind and 28.5% of them were able to read and write. The households who attended grade1-4 constitute 10 % and those who attended school from grade 5 to 8 account for 16.5%. The rest 5.5% of the respondents had completed grade 9 and above (see Figure 5). From this result it is evident that there is high illiteracy rate there which limits the farmers' access to different information sources and in turn, results in unwillingness to adopt and utilize new technologies in their agricultural practices.

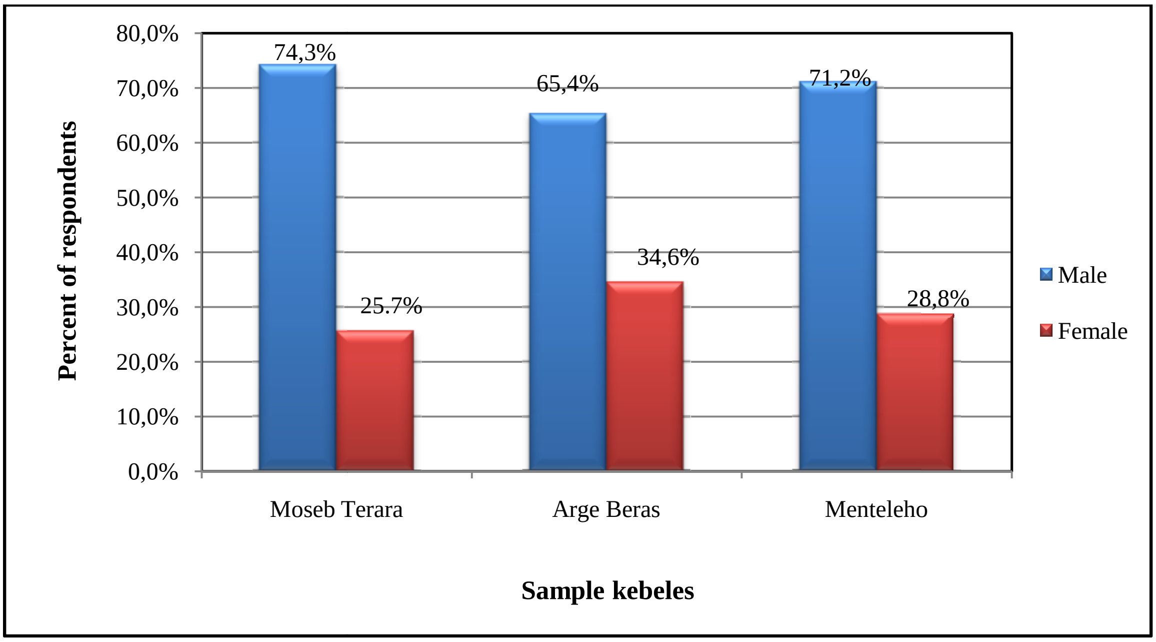

Figure 3. Distribution of sample household heads by sex (Survey result, 2013)

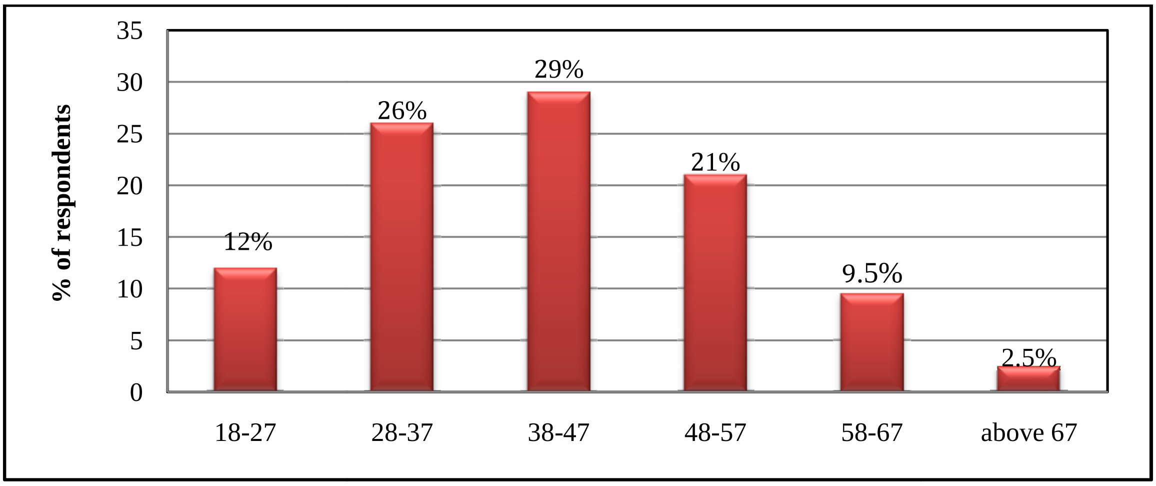

Figure 3. Distribution of sample household heads by age [Source: Survey result, 2013]

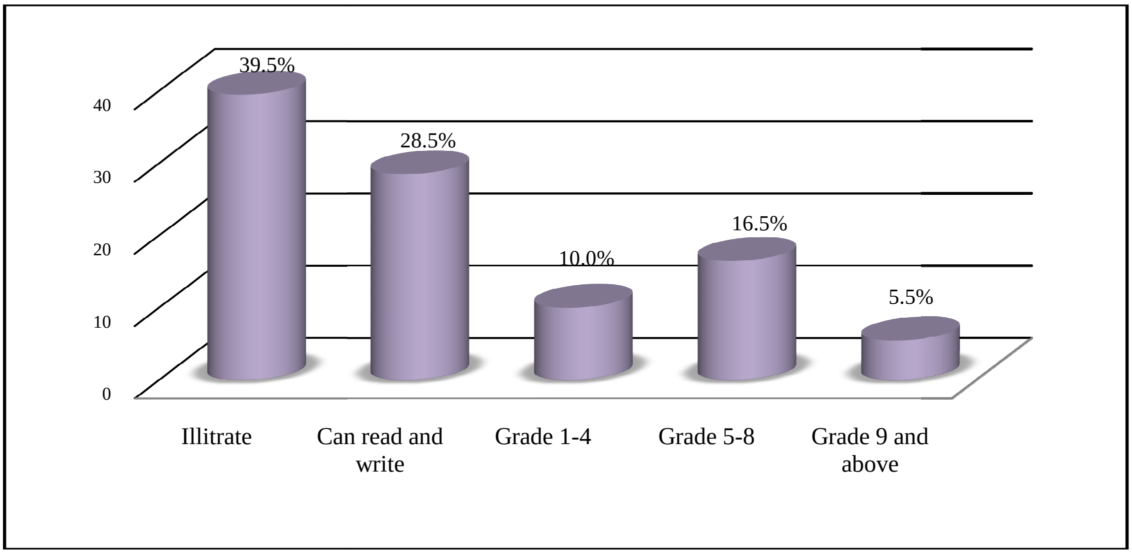

Figure 5. Educational levels of surveyed household heads (Source: Survey result, 2013)

Educational status of farmers is assumed to increase their ability to obtain and use agricultural related information and technology in a better way (Maddison, 2006; Deressa et al., 2009). However, low level of education and high illiteracy rate is typical in developing countries like Ethiopia which is one of the socio-economic features of households having crucial roles in increasing information about environmental problems in general and climate in particular. It also plays an important role in improving the productivity (at individual and community levels) by providing people with the skills and knowledge to actively participate in the economic endeavors of the society (Eyasu, 2007). Therefore, literacy has fundamental effects to implement adaptation strategies in order to mitigate the harmful effects of climate variability. Accordingly, the education characteristic of the households were examined in this study (refer Figure 5).

Economic characteristics of respondents

Land is the most economically productive natural resource on which the livelihoods of the people directly depends and enhance crop production and diversification for the agrarian communities of developing countries. It is the most important agricultural production factor in rural households. Although the idea of land distribution is to allocate land fairly to the landless rural population among the community partially based on family size (Desta, 2012) the re-distribution did not include all the landless young farmers due to low availability of cultivated land in Amhara Regional State (Anteneh, 2010). Therefore, the landholding sizes of the households were investigated in this study (see Figure 6).

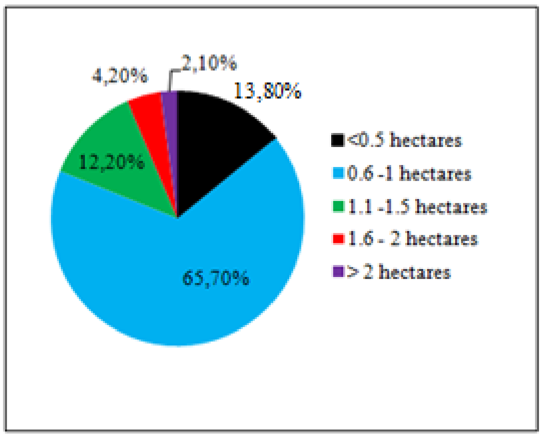

Figure 6. Landholding size of the sample household heads ([Survey result, 2013)

Figure 6 presented the summary of farmland sizes owned by the surveyed households. It is understandable from the figure that the majority of the surveyed households (nearly 68 %) owned too small farmlands of 0.6-1 hectares while 13.8% of them have less than 0.5, 12.2% own 1.1-1.5, 4.2% have 1.6-2 and about 2.1% have had greater than 2 hectares of farmland. This is an implication of limited adaptive capacity of the rural communities in the study area. In the light of this finding, several empirical works indicated that owning larger farmlands provide more opportunities to cultivate more crops and yield though it is noted that labor availability and financial capital affect the reality of how much land can be cultivated. Barungi and Maonga (2011) found out that less farmland area is often attributed to increased vulnerability of farming households to climatic risks.

Income is also another measure of agrarian communities' adaptive capacity. Household heads were asked to state their most important sources of income. The great majorities of the local people of Moseb Terara (93 %), Argeberas (99 %) and Menteleho (85 %) reported agriculture as their main source of income. Cereal crops have high contribution to the food security status of the rural households. As crops are major sources of their diet they keep crops for self-consumption and to generate income.

A small percentage of households in Mentehelo (19. %), Moseb Terara (10.5%), Arge beras (5.1%) rely on off-farm activities as alternative means of employment creation and income generation for landless and unemployed youth. The situation of off-farm activities were poorly expanded and subjected to the traditional cultural values and practices. In this regard, the focus group discussion indicates that engagement in weaving, fuel-wood sales, black smith, pottery and other handcrafts result in social alienation. Thus, the absence of off-farm activities would lead households to have limited income diversification and then vulnerability to drought and other weather-related shocks. However, engagement in off-farm activities like working on others farms, daily laborer and domestic work were widely practiced by the surveyed households in recent times.

Local communities' perception to temperature change

In an attempt to investigate whether farmers understand variability in climatic patterns, the respondents were asked questions related to their perception of temperature change. The survey result reveals that out of the total household heads, 87.5 % perceived that there was an increase in temperature over the last 20 years. Only insignificant proportions (1.0%) noticed the contrary, a decrease in temperature and 7.0% of them did not perceive any temperature change. However, the rest (2.5%) do not know any change in temperature (see Figure 7). According to the information obtained from the FGDs and key informant interviews, since 20 years ago the temperature pattern has changed and shown an increasing trend in amount and intensity. The highest temperatures were perceived in *Belg* (small rainy) season, namely in March, April and May. So, the result is consistent with the report of NMSA (2007), which states that almost the highest mean maximum and minimum temperatures were recorded in the *Belg* season of Ethiopia.

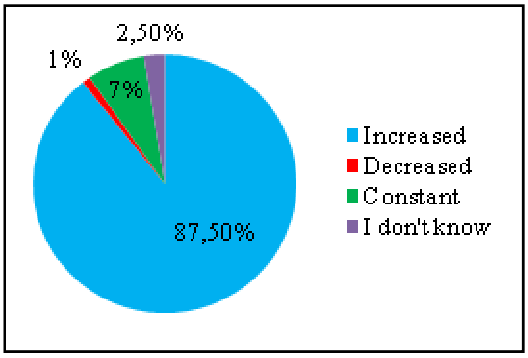

Figure 7. Distribution of respondents by perception to temperature trends (Survey result, 2013)

In addition to perceptions of communities' inter-annual temperature variability and trend, increasing deviation from the long-term average was observed in the study area over the same period (1979-2010) with immense potential environmental and production risks. The average temperature was taken for Lay Gayint worera and compared with the hottest and coldest temperature event of each year by calculating the temperature deviation using SPI formula based on Mongi et al. (2010) as observed in the woreda (see Figure 7).

Figure 8 demonstrates the maximum and minimum temperature deviations from the long-term average temperatures for the woreda. It is clear from the figure that in 1979 and 1980 both maximum and minimum temperature deviations were slightly above the long-term average temperatures. In 1981, 1982 and 1983 the two temperatures went in different directions (see Figure 8) while from 1984 to 1986 the maximum and minimum temperatures went down together. Indeterminate temperature fluctuation were observed from 1987 to 1996 (while the maximum went up and the minimum went down and vice-versa). Since 1997 both maximum and minimum temperature deviations were higher than the long-term average temperatures with greater fluctuations from time to time. The direction of temperature trend in the study area was found in line with other empirical studies by IPCC (2007) in the tropical regions of the world, Mongi et al. (2010) in Tabora region of Tanzania and Teshome (2016, 2017) in Ethiopia found out that both maximum and minimum temperatures showed increasing trends, all of which, pointed out that increasing temperature trend in the tropical and sub-tropical regions of the world is very high (IPCC, 2007) with adverse impacts on human and environmental systems. Also, the results differ from that of Shinyanga rural District study by Lyimo and Kangalawe (2010) who reported that both minimum and maximum temperature showed an increasing trend but the minimum temperature increased sharply while the maximum temperature increased gradually. This implies that different areas experiencing similar climatic conditions can experience changes in climate differently. The finding indicates that climate anomalies manifested in temperature rise and variability seeks serious attention in recent decades. Consistently, IPCC (2007) and NMSA (2007) reveal that there has been a very high warming and variable temperature trend over time. IPCC (2013) added that globally averaged combined land and ocean surface temperature data as calculated by a linear trend, show a warming of 0.85 [0.65 to 1.06] °C, over the period 1880–2012, when multiple independently produced datasets exist.

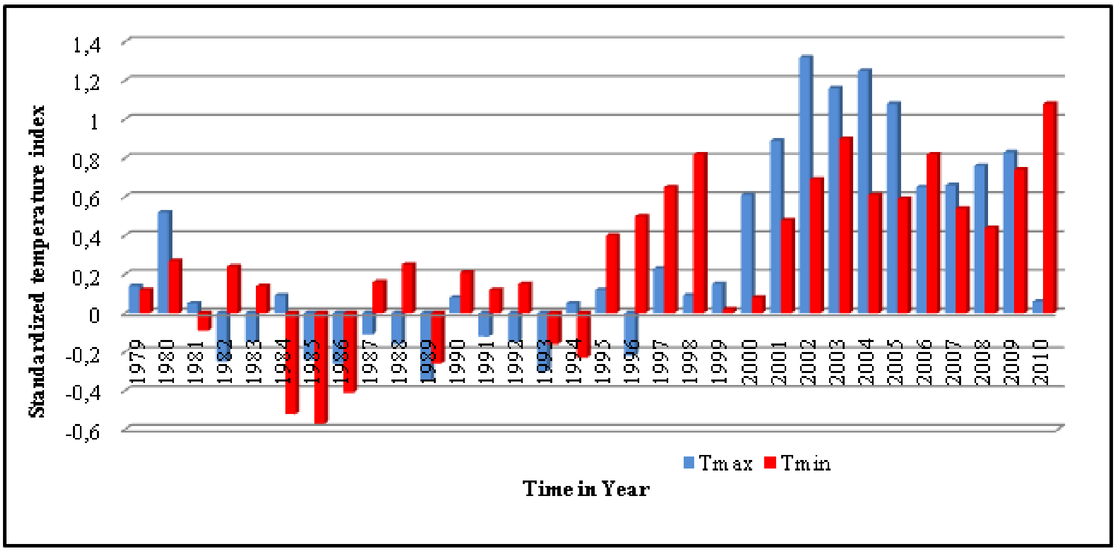

Figure 8 Maximum and minimum temperature deviations from the long-term average

The total increase between the average of the 1850–1900 and the 2003–2012 periods is 0.78 [0.72°C to 0.85" °C] based on the single longest dataset. Increases in temperature adversely affect crops especially in tropical and sub tropical areas where heat has become a limiting factor for crop production. The increase in temperature also increase evapo-transpiration rate of plants and increase chances for severe drought (IPCC, 2007). According to Deressa and Hassan (2009), climate change will reduce Ethiopian crop yields. Based on their studies by using three different models under different scenarios, income per hectare will decrease by 9.71% - 303.27% by 2050 and 10.3.391-418.01% by 20100. Besides the increasing temperature trends in the study area has paramount impact on water, land and vegetation resources through worsening evapo-transpiration with negative consequences on the productive capacities of these valuable resources. The IPC (2007) studies using 22/23 climate models confirm that temperature in Ethiopia increased at about 0.2° C per decade. The increase in minimum temperatures is more pronounced with roughly 0.4° C per decade whilst average precipitation remained fairly stable over the last 50 years in the country (Brohan et al. 2006; Schneider, et al. 2008).

Local communities' perception to rainfall anomalies

The perception of households towards rainfall patterns was measured in the numbers of perceived responses. Questions bearing four response options (increasing, decreasing, constant and don't know) were asked to the selected households (see Figure 9). Figure 9 presents communities' perceptions of temporal rainfall variability in the study area. It is evident from the Figure that the majority of the respondents (83%) perceived a decrease in rainfall amount; 6 % perceived an increase in it and 10 % of them perceived a constant distribution pattern. Meanwhile, 2 % of the farmers interviewed did not perceive whether there is a change or not in rainfall pattern. All the survey result regarding perception of households is consistent with the qualitative information obtained from FGDs and interviews.

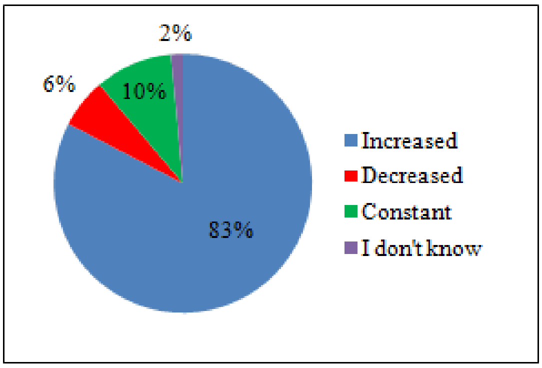

Figure 9. Proportion of respondents by their perception to rainfall pattern (Survey result, 2013)

FGD and interview participant community members as well as expert interviewees unanimously recognized the variability and changing patterns of rainfall amount, its timing and distribution in the study area over the past 20 years. Overall, increased temperature and declining rainfall are the predominant perceptions of the participants in the study areas. In addition to the perception of the community, drought analysis was done using standardized precipitation index. Drought is a natural hazard measured by shortage of precipitation that threats the natural resources and overall development efforts of specific places through exacerbating water shortage for some activity or for some social groups. Therefore, the difference in temporal patterns of drought, including duration, magnitude and severity, over a range of time scales is highly demanded for designing appropriate adaptation and mitigation measures. The long-term standardized rainfall anomaly index (SRAI) results are illustrated in Figure 10 for the study area.

Figure 10 demonstrates the standardized rainfall anomaly index (SRAI) in Lay Gayint woreda. It is clear from the Figure that the rainfall is characterized by fluctuation of wet and dry years in a periodic pattern. Out of 32 years of observation, the years 2002 and 2008 were severely and extremely dry respectively while the years 1995, 2004 and 2009 were moderately dry. These long-term dry conditions with precipitation deficiency had great influences on crop yields in the study area. On the contrary, the years 1979, 1986, 1994 and1998 were moderately wet while the years 1987 and 1989 were in very wet conditions. Only the years 1984 and 1990 received near normal rainfall amount (same to the long-term average rainfall).

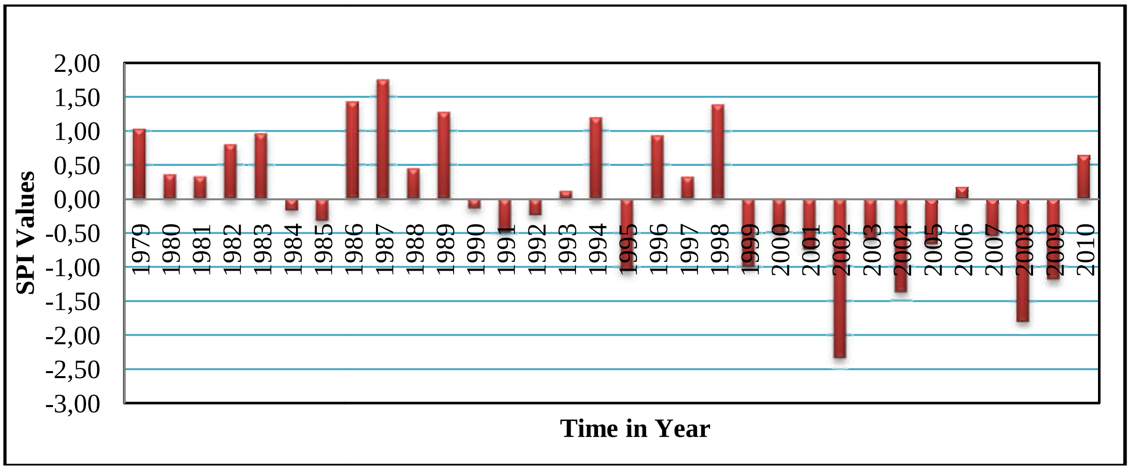

Figure 10. Standardized Precipitation Anomaly Index (SPI) from 1979-2010 (Source: NMA, 2011)

Table 3 presents the statistical analysis of daily precipitation data (1979 - 2010) with 11,322 daily records. It is clear from the Table that month to month rainfall variability is considerable across the years in Lay Gayint woreda. July (10.8583) and August (9.7475) had the highest standard deviation in the study area. The highest amount of average monthly rainfall was also recorded in July (276.04 mm with 30.66 average rainy days/PCPD) followed by August (231.21 with 30.77 PCPD), while the lowest was recorded in December (4.33 mm with 3.46 PCPD) closely followed by January (4.44 mm with 4.71 PCPD) and February (5.58 mm with 4.57 PCPD). From the analysis, it was observed that rainfall is usually at its peak between June and September which receive over 78.16 % of the rainfall amount in these months (see Table 3).

Table 3. Statistical Analysis of Daily Precipitation Data (1979 – 2010)

Number of years = 32
Number of leap years = 8 [A year, occurring once every four years, which has 366 days including 29 February as an intercalary day]
Number of records = 11, 322

Month	PCP_MM	PCPSTD	PCPSKW	PR_W1	PR_W2	PCPD
January	4.44	0.7663	9.4172	0.062	0.6242	4.71
February	5.8	0.9884	8.8894	0.0796	0.5313	4.57
March	42.78	4.4025	5.9381	0.1909	0.7051	12.89
April	46.09	3.9996	5.5654	0.2065	0.7685	15.06
May	39.91	4.2002	5.6768	0.1861	0.7073	12.89
June	76.25	5.3458	3.5684	0.3824	0.8458	22.23
July	276.04	10.8583	2.0983	0.75	0.9599	30.66
August	231.21	9.7475	2.5199	0.625	0.9629	30.77
September	83.67	4.328	2.6183	0.3189	0.8568	22.74
October	28.96	3.458	6.3218	0.0924	0.6667	7.8
November	14.15	2.3227	7.9265	0.0689	0.6369	5.11
December	4.33	0.9688	10.3122	0.0529	0.5702	3.46

PCP_MM = average monthly precipitation [mm]
PCPSTD = standard deviation
PCPSKW = skew coefficient
PR_W1 = probability of a wet day following a dry day
PR_W2 = Probability of a wet day following a wet day
PCPD = average number of days of precipitation in month

The standard deviation is important to show the spread of a probability distribution across months and years; it relates directly to the degree of uncertainty (insecurity) associated with predicting the value of a random variable. High standard deviation values reflect more uncertainty (insecurity) than low values. When the standard deviation values are examined, it is observed that the values of most months (June, July, and August) are higher than other months (see Table 4). The relation between the standard deviation and the average values indicate that deviation from the normal distribution cannot be ignored. The study result is in line with Famine Early Warning System Network (2008) study that states after a record harvest in October 2007, Ethiopia settled into a drought. Little rainfall was recorded during the October and November rainy season. Rainfall was also predicted to be below normal in the March-to-May rainy season and by the end of May 2008, millions of people faced with hunger in eastern Ethiopia as crops failed and food prices soared. Two successive seasons of poor rains left eastern Ethiopia in drought, and the effect on vegetation. This finding is also congruent with several empirical research findings. For instance, NMA recognized that food security, water and energy supply, poverty reduction and sustainable development endeavors are being challenged by current climate variability in Ethiopia through aggravating natural resource degradation and natural disasters (NMA, 2007). Other studies also reported the same (Kide, 2014; Lemmi, 2013; Assefa, 2011; Bryan et al., 2013). Similar results were again reported by Maddison (2006) whereby a significant number of farmers in eleven African countries believed that temperatures had increased and precipitation had declined.

Farming communities' adaptation strategies to climate change

Rural communities have many ideas on how to prepare for future climate variability with a strong motivation to move out of poverty. Similarly, the rural communities of Lay Gayint woreda implement different physical and institutional adaptation strategies to combat the long-term impacts of climate variability and/or climate change. Adaptation strategies are methods the local people use to adjust themselves with the existing climate variability and climate change. Adaptation to climate variability is a two-step process which requires that farmers perceive climate variability in the first step and respond to variability in the second step through adaptation. This is very important to manage future patterns of climate variability. Therefore, the adaptation methods were identified by asking the farmers about their perceptions of climate variability and the actions they take to counteract the negative impacts of climate variability (Maddison, 2006;

Mentez et al., 2008; Deressa et al., 2009; Bryan et al., 2013).

Physical adaptation strategies: This study tried to identify the physical adaptation options used by the studied rural communities to mitigate the adverse impact of climate variability and/or climate change and associated extreme climatic events such as droughts, flooding, hailstorms, and soil erosion (refer to Figure 11).

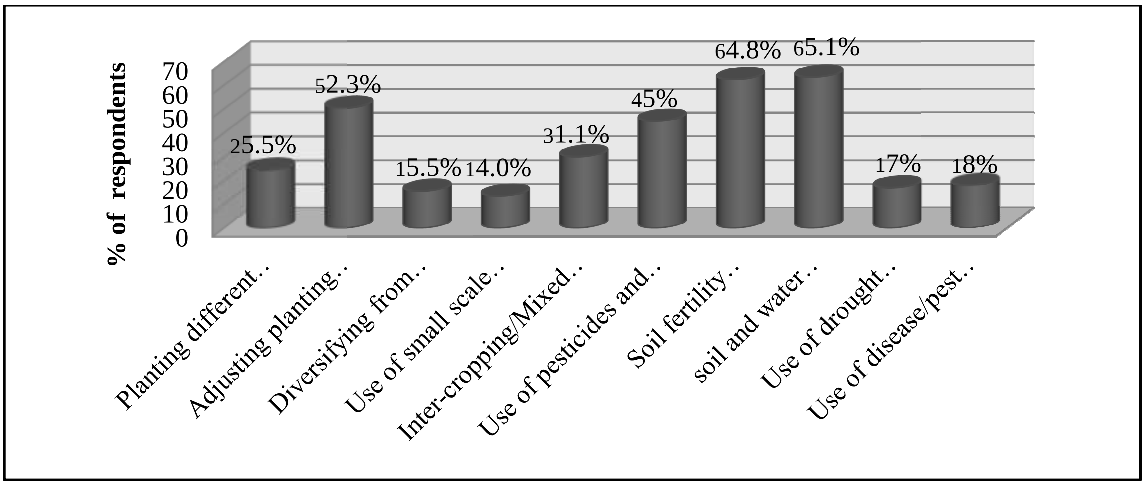

Figure 11. Respondents' physical adaptation strategies to climate change [Survey result, 2013]

Figure 11 presents the physical adaptation practices used by rural communities against climate variability. Physical adaptation strategies focus on tactic decisions made in response to seasonal climate variability. It is clear from the Figure that, 65.1% of the respondents use soil and water conservation measures, 64.8% of them use soil fertility management and 52.3% use adjusting planting and harvesting dates as their methods of adaptation to the negative impact of climate variability. This implies that soil and water conservation, soil fertility management and adjusting planting and harvesting dates were the main physical adaptation measures used by the farmers. Soil conservation techniques, particularly constructing terraces, building check dams and planting trees were found to be the main soil conservation measures used by the community of the study area for the purposes of avoiding the risk of flooding and soil erosion. According to the information obtained from FGDs, the farmers in each kebele were participating in a new system of adapting natural resource conservation methods, the so called five men strategy which participate people for different farming activities and natural resource conservation. Five people work in one group, and the number of groups in each Kebele varies based on the population number reside there.

With regard to inter-cropping/mixed cropping and planting different varieties of crops, 31.1% of the respondents use them to adapt to the impact of climate variability and climate change; whereas small scale irrigation (14.0%) is the least practiced adaptation strategy among the major practices identified in the study area. The limited use of irrigation is attributed to the need for more capital, shortage of water and low potential area for irrigation. Ethiopian agriculture is heavily dependent on natural rainfall, with irrigation agriculture accounting for less than 1% of the total cultivated land in the country (FEDP, 2008). These results suggest that respondents employed one form of adaptation strategy or the other in order to reduce the effect of climate change on food crop production. The interview participants and observation verify that conservation tillage, intercropping and crop rotation are also employed by the households of the study area in their farming practices. According to Environmental Protection Authority EPA (2010) of Ethiopia, the use of these three agronomic practices will enhance the long-term sustainability of soils and improve the resilience of crops to the impact of climate variability and/or climate change. Smith (2000) added that changes in cropping systems can offset many of the potentially negative impacts of climate variability and/or climate change.

Institutional adaptation strategies: Local governments are implementing different institutional adaptation strategies in response to the impact of climate variability and/or climate change. The finding shows that 53.4 % of the surveyed households received extension service (see Table 4) which would enhance efficient decision-making on the choice of adaptation strategies. The household survey indicates that out of the total sampled households 48.2% had access to credit whilst 51.8% of them were missing this opportunity. In order to reduce the negative effects of climate variability and/or climate change access to climate information deemed necessary. However, only 24.6% of the households obtained climate information which limits the households' ability to get the necessary technology and resources. About 32.8% of the respondents also obtained early warning information from disaster prevention office of the study area (see Table 4).

Table 4. Institutional adaptation strategies to climate variability used by the respondents

Institutional adaptation strategies	Freq.	Percentage
Early warning system	63	32.8
Information on climate	47	24.6
Access to credit for purchasing fertilizers	93	48.2
Access to extension service	103	53.4
Access to safety-net program	82	42.5

Source: Survey result, 2013

Over 42 % of the respondents reported access to social security program (Safety net program) indicating the severity of climate-induced hazards like recurrent droughts, flooding, hailstorms and different crop, animal and human disease. In line with this survey report the FGDs and interview participants reported that the government supports those 42.5 % critically food insecure households have been beneficiaries of the productive safety net program starting from 2005. Institutional adaptation strategies focus on strategic national decisions and policies on local to regional scales taking into account long-term variability and change in climatic conditions. Strengthening access to extension and credit services were the dominant institutional adaptation strategies given to the farmers in the study area. Lipper et al. (2014) noted the importance of institutional adaptation measures to the most vulnerable smallholder farmers to cope with the impact of climate variability as they lack financial, technical and political means to support adaptation efforts. Same authors stressed that without access to information, technology, markets, finance, institutional support and decision making opportunities, smallholder farmers are powerless to respond to the challenges of climate variability. Mahmud et al (2008) argued that access to future climate information, agricultural extension and credit services are determinant factors that create difference on farmers to take adaptation measures. This was also recognized by Bekele (2003) who noted that farmers with significant extension contacts have better chances to be aware of changing climatic conditions and adaptation measures in response to climate variability. Nhemachena and Hassan (2008) in their findings of the study highlighted that access to affordable credit increases financial resources of farmers and their ability to meet transaction costs associated with various adaptation options they might want to take. McSweeney et al. (2008) encourages reactive adaptive measures at national and local levels to combat climate change impacts and to ensure the nation's food security.

Crop diversification (CD): CD is the most important adaptation method in reducing expected climate variability and/or climate change-induced risks through reducing both natural and economic uncertainties. A change in cropping pattern implies a change in the proportion of area under different crops in the farmlands. It is also a shift from low-value to high-value agriculture for enhancing agricultural output. However, the cropping pattern in an area depends mostly up on agro-climatic, technical and institutional factors (Vaidyanathan, 1992). In addition to reducing natural and economic uncertainties CD is very much important to enhance nitrogen in the soil to replenish the soil fertility and to provide a reasonable quantity of the costly organic fertilizers for farming communities (Hussain, 2009). Households who have cultivated diverse crops can also stagger his/her income all over the year and positively influence the adaptation decision. In the light of this, Smith (2000) states that income source diversification is an adaptation strategy which has the potential to reduce vulnerability to climate related asset losses. The survey result indicated that the major source of the respondents' income is agriculture, mainly crop production. This finding is supported by Lemmi (2013) which indicated that the major source of the households' income was agriculture. Mahmud et al. (2008) in his study pointed out that crop is the major staple food, foreign exchange earner and source of income for the majority of the people in Ethiopia. Therefore, farming communities should be encouraged to adopt CD to reverse the harmful impact of current and future climate variability and/or climate change. Although the application of CD in the study area is too small its use is associated with low cost and ease of access by farmers. This argument has been supported by previous studies (Lemmi, 2013; Meseret, 2009).

Taking into account the multidimensional benefits of CD in managing risks and ensuring food security, this study investigated the patterns, trends and determinants of CD in the study area using primary data for a period of one year (2010-2011).The result found out 0.11 CDI showing that the cultivated land is dominated by one or few crops in the study area (refer Table 5). This might be due to various inter-related factors. Although the majority of the local people are engaged in crop production as their main source of income the result of crop diversification index (CDI) was very small (0.11 index score) indicating that the cultivated land is dominated by few crops in the study area (see Table 5).

Table 5. Average area coverage of crops in the year 2011/12

Major crops	**Area coverage in hectare**	**Percentage**
Wheat	58.97	32.28
Teff	30.42	16.65
Barely	26.88	14.71
Pea	24.99	13.68
Beans	15.38	8.42
Lentil	11.94	6.53
Sorghum	8.00	4.38
Cheek pea	2.75	1.51
Haricot been	2.00	1.09
Sunflower	1.38	0.76
Index	**-**	**0.11**

Source: Survey result, 2013

The rugged natures of the topography, land shortage, rainfall variability, poor soil conditions and in turn limited irrigation facilities have influenced CD. In the light of this, Kankwamba et al. (2012) stated that CD is determined by rainfall distribution. Bhattacharyya (2008) realized that CD is more prominent in rain-fed areas than in irrigated ones. This implies that there is need to encourage farmers to do their tillage during the rainy season by the help of extension workers. There is also a need for substantial investment in reliable weather information dissemination systems pertaining to climatic conditions to reduce the adverse effects of unpredictable rainfall patterns.

The sources of livelihood for the rural communities is highly attached to farmland and related resources. The size of farmland has affected communities' food security status. Rehima et al. (2013) report that smallholder farmers only depend on one type of crop for their livelihood in Ethiopia. According to Aberra (2002), access to farmland is affected by the rapid population growth which resulted in diminution of farm sizes, increase landlessness and food insecurity in many developing countries. Similar to most highlands of the country, the landholding of farmers in the study area is very small. This study is congruent with that of Growth and Transformation Plan/GTP (2016) of Ethiopia that the majority of smallholder farmers are practicing subsistence farming on less than one hectare of land. According to the information obtained from the interviewed famers and extension agents in the study sites land size positively influence households' crop diversification decisions. The more the land size owned by the farmers the more the probability of diversifying crops. In fact, larger farm sizes may enable households to allot their land to multiple crops than smaller holdings. Other previous studies also indicated that land size positively affected crop diversification (Bonham et al., 2012). On the contrary, the study in eastern Hararghe highlands of Ethiopia revealed that CD has shown an increasing trend from 2004 to 2009 production periods (Mesfin, 2012).

Conclusions

Both the meteorological data and local communities' perception showed considerable long-term climate variability from the period 1979 to 2010. The majority of the rural households indicated that they had observed increased temperature and drought and decreased rainfall amount and/or erratic in distribution. This implies that the impact of climate variability and/or change in the study area is at the community level. The standardized precipitation anomaly index (SPI) characterized the woreda rainfall by fluctuation of wet and dry years in a periodic pattern. Extremely and severely dry years were observed in 2002 and 2008 respectively with great impact on crop yields in the study area whilst only the years 1984 and 1990 received near normal rainfall amount. In response to long term perceived changes, farmers have adopted different strategies to cope up with the consequences of climate variability and to manage future patterns in climate variability. In this study, adaptation measures have been placed in two main categories: physical and institutional adaptation strategies. Soil and water conservation, soil fertility management and adjusting planting and harvesting dates were the main adaptation measures used by the farmers in the first (a) category. Although some local communities' adaptation strategies to climate change are not sufficiently supported by extension service, credit, small-scale irrigation, and safety-net program were the major institutional adaptation strategies given to the farmers. Crop diversification index is found very low (0.11) indicating that the cultivated land of the study area is dominated by one crop due to small land holding size, limited irrigation facilities, rainfall variability, rugged topography and poor soil. In conclusion, ecologically designed agricultural systems that can provide a buffer against extreme events need to be the primary concerns of the State government to minimize climate-induced risks on the livelihoods of rural households. Local leaders should enforce integrated land management practices that enable to regulate the local climate and reduce the risks of drought and flood. Farmers also should be encouraged to use agricultural technologies, like conservation farming, drought tolerant crops, nutritional gardens, diversifying non-farm income and linking food relief to community development which would help farmers militate against climate variability and/or climate change. In this regard, research should be done to find drought and frost tolerant crop varieties.

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