ANALYSIS OF CLIMATE CHANGE TREND, IMPACTS ON FARMERS AND THEIR ADAPTATION STRATEGIES IN KOLA TENBEIN WOREDA, CENTRALTIGRAY, NORTHERN ETHIOPIA

M .Sc. THESIS

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THESIS SUBMITTED TO THE

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN“CLIMATE SMART AGRICULTURAL LANDSCAPE ASSESSMENT”

OCTOBER, 2019

APPROVAL SHEET

This is to certify that the thesis entitled "Analysis of Climate Change Trend, Impacts on Farmers and their Adaptation Strategies in Kola Tenbein Woreda, Central Tigray, Northern Ethiopia" submitted in partial fulfillment of the requirements for the degree of master's with specialization in Climate Smart agricultural landscape assessment**,** the graduate program of the department of**,** Agroforestry and has been carried out by Getachew Teklehaymanot Belay i.d.no 011/10 csalsa, under my/our supervision. Therefore I/we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

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Name of Main advisor	*Signature*	*Date*

THESIS ACCEPTANCE SHEET

This is to certify that the thesis entitled "Analysis of Climate Change Trend, Impacts on Farmers and their Adaptation Strategies in Kola Tenbein Woreda, Central Tigray, Northern Ethiopia" has been Submitted in Partial Fulfillment of the requirements for the master of Science degree in climate smart agriculture and landscape assessment and it is a record of original research carried out by Getachew Teklehaymanot Belay. i.d.no. M.Sc./csalsa/011/2010, under my supervision, and no part of the thesis have been submitted for any other degree or diploma. The assistance and help received during the course of this investigation have been duly acknowledged. Therefore, I recommend that it be accepted as fulfilling the thesis requirements.

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Getachew Teklehaymanot

ABBREVIATIONS AND ACRONYMS

AIACC	Assessment of impacts and adaptation to climate change
CEEPA	*Centre for Environmental Economics and Policy in Africa*
FAO	Food and Agricultural Organization
FDRE	Federal Democracy Republic of Ethiopia
FGD	Focus Group Discussion
GDP	Gross Domestic product
GEC	Global environmental change
GHGs	Green House Gases
GTP	Growth and Transformation Plan
IPCC	Intergovernmental panel on climate change
KII	Key Informants Interview
Masl	meter above sea level
MoA	Ministry of Agriculture
MoFED	Ministry of Finance and Economic Development
NAPA	National Adaptation Program of Action
NMA	National meteorology Agency
PASDEP	Plan for Accelerated and Sustainable Development to End Poverty
SD	standard deviation
SPI	Standardized precipitation Index
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention for Climate Change
UNISDR	United Nations International Strategy for Disaster Reductions

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ABSTRACT

Climate change is a serious threat to the livelihoods of rural communities, particularly in arid and semi-arid zone areas. In this study areacarried out analysis of climate change trend, impacts on farmers and their adaptation strategies in kola Tenbeinworeda, Tigray region. Ethiopia. Rainfall and temperature data have been analyzed using coefficient of variation standardized Precipitation Index and furthermore, excel and Minitab software used to detect the time series trend. The survey data was collected by using household questionnaire, key informant Interview, focus group discussion and analyzed by SPSS software. In the study area the past 40 years annual rainfall higher variability in lowland (kola) than high land (Dega). A statistically significant difference coefficient of variation higher in lowland (kola).In study low land woreda the dry years were occurred in 1983, 1984, 1987, 1988,1995,2000,2002, 2008 and2009, extreme wet year in 1979. In high land woreda the dry years were occurred in 1982, 1983, 1984, 1994, 1996 and 2006. More dry and extreme wet years occurred in low land (Kola). The month June, July and August the main rainy season, the rainfall amount clearly showed significant variability and declining trends in annual and summer rainfall. It is also that the average annual minimum temperature is increasing faster than average annual maximum temperature, more drought-inducing events in the study woreda. The survey result showed in study area Climate change impacts Stated by household respondents include deceased agricultural yield, frequent drought and reduced water availability on average a statistically significant difference of climate change impact in low land (87%) than high land (54%) and mid land (73%). The major adaptation strategies employed by the majority household respondents include soil and water conservations, irrigation schemes, moisture stress resistant crop varieties, crop diversification and shifting cattle's to small ruminants, on average a statistically significant difference of adaptation strategy prioritized in low land (82.1%) than high land (53%) and mid land (78.1%). Leading us to conclude strategies designed in the agricultural sector have to take the declining and variability of rainfall and increasing trend of temperature inducing to drought events need Adaptation strategies designed into rural small holder's farmers.

***Key Words**: Climate Change, Trend, Rainfall, Temperature, Adaptation strategy*

1. INTRODUCTION

1.1.Background and Justification

Changes in temperature and rainfall patterns are widely observed in many semi-arid parts of the developing world that are likely to become even hotter and dryer with time (Collier *et al*., 2008). Rainfall and temperature is the key factor for agricultural production. Agriculture remains by far the most important sector in the Ethiopian economy. The sector directly supports about 85% of the population in terms of employment and livelihood; contributes about 50% of the country's gross domestic product (GDP); generates about 88% of the export earnings; and supplies around 73% of the raw material requirement of agro-based domestic industries. *(CEEPA, August 2006)*

O'Brien *et al.* (2006) perceive climate change as the natural phenomenon that is accelerated by human activities. This is in agreement with the United Nations Framework Convention on Climate Change (UNFCCC) (2006) which referred to climate change as effects of direct or indirect human activities, leading to changes in global atmospheric components that create changes of natural climate variability observed over comparable time.

Annual agricultural production shows variability due to wide variation of rainfall in magnitude and distribution both in space and time. Moreover, the agriculture in Ethiopia is practiced under the condition of diminishing farm size, high soil degradation, imperfect agricultural markets and poor infrastructure, absence of improved agricultural technologies, and lack of adequate financial services (Challa and Tolosa, 2012).As a result, agricultural productivity in Ethiopia appears to be poor and highly susceptible to minor climate change such occurrences have made the country vulnerable to famine and food insecurity. Rain failures have contributed to crop failures, reduction in crop and livestock yield, deaths of livestock, hunger and famines in the previous decades. Even relatively small incidents during the growing season, like too much or too little rain at the wrong times, can result in disasters (NMA, 2006).

Small holder farmers and cattle herders, who are already struggling to cope with and manage the impacts of current climate change, climate Variability and poverty, could face daunting tasks to adapt to future climate change. Over the years, recurring chronic food crisis and famine resulting from frequent droughts; environmental degradation and decline in food production had severely damaged the country's economy many times and still remain major challenges to the country (Aklilu and Alebachew, 2009).Acknowledging the vitality of enhancing policy towards tackling the challenges that climate change poses to farmers, stressed that it is important to have an understanding on their perceptions of climate change, potential adaptation measures and factors affecting adaptation (Banjare, 2015).

Tigray is also one of the Regional States in Ethiopia that is frequently affected by drought and other related hazards because it has both arid and semi-arid nature. Consequently, the impacts of climate change and variability remain a serious challenge. Rainfall being an important climatic element, the assessment of climatic variation and the consequent impact on farming systems is importance as information in this regard. This dissertation was profoundly designed to study linkages between perceptions on climate change; adaptation strategy adopted by smallholder farmer in the study area and understanding the impact of climate change on agricultural production, and identified the determinants of adaptation method used by Farmers located at each agro-ecological zone of study woreda.(Bureau of agriculture and natural resources, 2015)

1.2.Statement of Problem

Ethiopia is an agrarian country which is challenged by both social and natural problems. The main social problem is poverty which is largely associated with high population growth, a low level of institutional and infrastructural development and a limited use of agricultural technology (Admassie and Adenew, 2007).

A recent study by UNDP (2008) also indicates that climate change in Ethiopia could lead to extreme temperatures and rainfall events, as well as extended droughts and floods. Accordingly, considering the fact that the country is highly dependent on the agricultural sector for income generating and food security. Erratic precipitation would adversely affect the lives perhaps the majority of the populations (Haile, 2005).

In Ethiopia, the agriculture sector being predominantly dependent on rainfall and temperature.The connection between drought and crop production failure is widely known. Climate of Ethiopia which has remained relatively static for years has now become very dynamic and unpredictable and has brought worst effects on the agriculture sector by affecting the two most important direct agricultural inputs, precipitation and temperature (Deschenes and Greenstone, 2006).Tigray region is one of arid and semi-arid nature in Ethiopia that is frequently affected by drought, agricultural production failure and other related hazards, the impacts of climate change and variability remain a serious challenge. According to the source (FDRE, 2011).

1.3.Objective

1.3.1. General Objective

The general objective of the thesis analysis of Climate Change trend, impacts on farmers and their adaptation strategy in kola Tenbein woreda, central Tigray, northern Ethiopia.

1.3.2. Specific Objective

1. Analyzes climate change trend though meteorological data in low land (Kola) and high land (Dega) agro ecology in study woreda.

2. Identify the causes of climate change and impacts on the study woreda by household survey.

3. To ensure small holders farmers adaptation strategies to avert problems arising due to climate change in the study woreda.

1.4.Research Questions

1. What are the major variables indicators in the occurrence of climate change and its trend in the study woreda?

2. How do affect climate change in the livelihoods of the rural households in different agro ecology?

3. What are the adaptation strategies to climatic change impact designed by smallholder farmers in rural community?

2. LITERATURE REVIEW

2.1. Concept of Climate Change in Global Context

Climate change has moved from being a hypothesis to being a reality. This is substantiated by the fact that the global average surface temperature of the earth has increased by 0.6±0.2°c since 1900 and it is likely that the rate and duration of the warming are greater than at any time in the past 1000 years (Intergovernmental Panel on Climate Change (IPCC), (2001a)).

Climate change has been defined by IPCC (2007) as a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate, however, is only one factor within the dynamic earth system. Changes in the physical and biogeochemical environment, either caused naturally or influenced by human activities such as deforestation, fossil fuel consumption, urbanization, land reclamation, agricultural intensification, freshwater extraction, fisheries over-exploitation and waste production, contribute to global environmental change (GEC), (CCAFS, 2009).

2.2. Climate Change and Variability

Climate Change and Variability indicated the third assessment report of the international panel on Climate Change (IPCC) that developing countries are expected to suffer most from the negative impacts of climate change and climate variability (IPCC, 2001). This is attributed to the fact that climate change and variability is expected to affect the two most important direct agricultural production inputs: precipitation and temperature. These inputs are crucial for livelihoods in Africa, where majority of the population relies on local supply systems sensitive to climate variation. (Deschenes and Greenstone, 2007).

As the adverse impacts become more frequent and severe, the already fragile socioeconomic activity of the continent is more likely to exacerbate (Collier *et al*., 2008). Funk et al. (2005) reported that rainfall in Ethiopia is expected to decline in the future and also become more irregular. Recent observational and modeling studies showed that the warmest temperature extremes, particularly those derived from minimum temperature, have significantly increased over the 20th century and will continue to increase throughout the 21st century. Evidences suggest that globally, there have been more flood/drought-inducing events, which are set to escalate in frequency and intensity in the future (Sarah, 2002;Tebaldi et al., 2006).A recent study by (UNDP, 2008) also indicates that climate change in Ethiopia could lead to extreme temperatures and rainfall events, as well as more heavy and extended droughts and floods. Accordingly, considering the fact that the country is highly dependent on the agricultural sector for income and food security, erratic precipitation would adversely affect the lives perhaps the majority of the populations (Haile, 2005).(Dercon, 2004) reported that in Ethiopia, a season with starkly reduced rainfall depressed consumption even after four to five years.

2.3.Impacts of Climate Change

Smallholder subsistence farmers are among the worst hit by climate change due to their low adaptive capacity and their dependence on rain-fed agriculture which is very sensitive to climate variability (IfejikaSperanza, 2010; Easterling, 2011). In Africa, precipitation amounts are likely to decrease for most parts of Sub-Saharan Africa (SSA) while rainfall variability is expected to increase (IPCC, 2014). IfejikaSperanza (2010) and World Bank (2010)argued that Africa is expected to experience mainly negative climate change impacts, in terms of an increase in the already high temperatures and decrease in the largely erratic rainfall in its context of widespread poverty and low development. Africa, due to low adaptive capacity and high sensitivity of socioeconomic systems, is one of the most vulnerable regions highly affected and to be affected by the impacts of climate change (IPCC, 2014). By 2100, parts of the Sahara are likely to be the most vulnerable, showing likely agricultural losses of up to 7% of GDP (Below et al., 2010). UNDP (2014) stressed that the adverse impacts of climate change will be felt most acutely by the smallholder farmers in developing countries because they are by large dependent on natural systems for growing crops and raising livestock Current climate variability is already imposing a significant challenge to Ethiopia by deterring the struggle to reduce poverty and sustainable development efforts (NMA, 2007). World Bank (2010) has ranked Ethiopia among the most vulnerable countries in the world to the adverse effects of climate change; mainly due to its high dependence on rain fed.

Climate change is taking place at a time of increasing demand for food, feed, fiber and fuel, and has the potential to irreversibly damage the natural resource base on which agriculture depends. Changes in carbon dioxide concentrations, temperature and rainfall will have an impact on plant cover and land use which, in turn, substantially affect the behavior of water when it falls as rain, (Muller, 2007). Due to reduced adaptive capacity and higher climate vulnerability smallholder and subsistence farmers in developing countries may not be able to cope with climate change effectively and such conditions pressure to cultivate marginal land or adopt unsustainable cultivation practices is likely and may increase land degradation, water scarcity and endanger biodiversity. Consequently, the impacts of climate change and variability remain a serious challenge. According to FDRE 2011 study, by 2020 in Ethiopia, the yields from agriculture could fall by 50 % because of the adverse effects of climate change like rise in temperature, drought, flood, erratic rainfall distribution and others.

2.4.Climate Change Trend

Different trend analysis studies have been conducted in Ethiopia at different spatial-temporal scales and came up with mixed results. A study by Gebremedhin *et al. (*2016) in Northern Ethiopia disclosed mix of non-significant positive and negative trends. Daniel et al. (2014) revealed. A statistically significant increasing trend of temperature while the case for precipitation was mixed over the upper Blue Nile river basin of Ethiopia. Seifu and Abdulkarim (2006) had tried to cover relatively wider spatial coverage and kiremt rainfall exhibited a significant decreasing trend. Negash et al. (2013)had investigated the spatiotemporal variability of annual and seasonal rainfall over Ethiopia and reported decreasing trends of kiremt and annual rainfall in northern Ethiopia The average temperature rise in Africa is faster than the global average and is likely to persist in the future. This warming occurred at the rate of about 0.5ºC per decade with a slightly larger warming incrops are grown close to the thermal tolerance limits(Collier et al., 2008).

2.5.The Performance of the Agricultural Sector in Ethiopia

Agriculture is the most important sector in the Ethiopian economy for the following reasons (I) it directly supports about 85% of the population for its employment and livelihood sources and food security; (II) it contributes about (41 %) to the country's gross domestic product (GDP); (III) it generates about 90 % of export earnings; and (iv) it supplies around 70% of the raw material requirements of agro-based industries. In addition agriculture plays a key role in generating extra capital to accelerate the country's overall socio economic development.*(CEEPA, August 2006)*

Reviews by Samuel (2006) indicates that the agriculture in Ethiopia is practiced under the condition of diminishing farm size and a survey in the 2000 cropping season revealed that about

87.4% of rural households were holding less than 2 hectares; whereas some 64.5% cultivated farms less than one hectare; while 40.6% operated land size of 0.5 hectare and less. The same source indicates that the average farm size in the highlands (in 2004) was fragmented into 2.3 plots, each with 0.35 hectares; and about one third of surveyed farms consisted of 3 or more plots. Likewise World Bank (2005) noted that per capita land holding in rural areas in the highlands has fallen from 0.5 hectare in the 1960s to only 0.2 hectare by 2005, and the marginal productivity of labor is estimated at close to zero.

The abundant human labor of the country is unemployed or under employed, and concentrated in the rural highlands. Population pressure has led to encroachment for cultivation into forest areas and steep slopes prone to soil erosion. This creates serious effects on the environment, which, together with fluctuation in rainfall, has made agricultural production very vulnerable to weather shock. Farm fragmentation has increasingly emerged as one of the key problems of subsistence farming of Ethiopia and the average farm size is considered by many to be small to allow sustainable intensification of smallholder agriculture. It is also noted as one of the factors that constrains farm income and the level of household food security (Samuel, 2006).

2.6.Past Trends of Climate and its Impacts

The climate of Ethiopian is described by incidents of climate extremes, such as drought and flood, and rising temperature and declining precipitation and irregular patterns. The history of climate extremes, especially drought, is not a new phenomenon in Ethiopia (NMS, 2007).

Even though drought is not a new phenomenon in Ethiopia, its occurrence frequency has increased in some areas and likewise the variability in rainfall patterns (Skambraks, 2014). Vulnerability to drought in Ethiopia is associated to a number of factors and one of the reasons is related to the exceedingly low level management of water resources either in the form of watershed management or investment in water infrastructure (World Bank, 2006). On an aggregate level, Ethiopia's economy will remain highly vulnerable to exogenous shocks, mainly because of its dependence on primary commodities and rain fed small-scale and subsistence-oriented agriculture.

Studies indicate that temperature and precipitation have been changing over time. Accordingly minimum temperature has been increasing by about 0.37 degrees Celsius every decade during the past 55 years. The average annual rainfall of the country has recently shown a very high level of variability (NMS, 2007). For the past five and half decades a few years were characterized by dry conditions, resulting in drought and famine, whereas others are characterized by wet conditions. Droughts do not only reduce agricultural production, but also result in starvation, death, and foreign aid dependence. Droughts are a key reason for Ethiopia's large dependence on foreign food aid.In this regard FAO (2016) in its analysis of climate change and food security strongly advocated the need for investing in systems to assess risks, vulnerabilities and adaptation options and also strengthening adaptation through policies and institutions.

2.7.Climate Change of Adaptation Strategy

In Ethiopian both farm households and the government undertakes climate risk management through mitigation and coping practices to reduce the damages from climate change. Climate adaptation strategies at the household level include diversifying crops, mixing crop and rearing of different livestock species, and accessing of rotating credit arrangements. According to Deaveux and Guenther (2007) there are a number of coping strategies at the household level including: selling productive assets, selling livestock and agricultural products, reducing current investment and consumption, employing child labor, temporarily or permanently migrating, mortgaging land, and using inter household transfers and loans. Community-level risk aversion and mitigation strategies include water harvesting, resource conservation and management, irrigating, voluntary resettlement programs, using household extension packages or agro ecological packages, and joining productive safety net programs. Important government-driven coping strategies include food distribution of food mainly obtained from food aid, and food-for-work programs (MoFED, 2007). In fact, food aid has become one of the most important coping strategies for fighting drought and famine. In general, poor performance in the agricultural sector is associated with poverty where there is inadequate investment in institutions, infrastructure and agricultural technology generation, and these entire make farmers become liable to climatic distress such as droughts.

2.8.Indigenous Knowledge of climate change adaptation

Integrating indigenous knowledge into policy frameworks for climate change can lead to the development of effective adaptation strategies that are profitable and sustainable (Ajani *et al.*, 2013; Nyong 30 *et al.*, 2007; Robinson and Herbert, 2001). Communities and farmers in Africa always strive to withstand the changing environments. They have the knowledge and practices to cope with basic environmental conditions and climatic and other natural shocks. The development of indigenous capacity is a fundamental intervention for local community empowerment and effective participation of the community in the development process (Leautier, 2004*)*. In many parts of Africa local farmers apply farming practices such as the use of zero-tilling in cultivation and mulching. Use of mulches moderates soil temperatures, suppress incidence of diseases and damaging pests, and retain soil moisture (Dea and Scoones, 2003).

3. MATERIALS AND METHODS

3.1.Description of the Study Area

3.1.1. Topography

This study area was located in kola Tenbein woreda, central zone, Tigray region, Northern Ethiopia totally twenty seven kebelles in different agro-ecology in high (Degas) kebelle1% found between 2400 and 2553 masl, mid land (weynadega) kebelles 81% lying between 1500 masl to 2400 masl and low land (Kola)kebelles 18% lying 913 to 1500.source (Bureau of agriculture and natural resources, 2017)

3.1.2. Location

Kola Tenbein woreda is found 823km and 40 km far from the capital city of Ethiopia (Addis Ababa) and capital city of Tigray regional State (Mekelle) respectively in northern Ethiopia. It is situated between53^{0} 59’31”N and 45^{0}60’73” E. This woreda is bounded in different woreda in the north Tanque Abergelle, in the South Naeder Adet and WerieLekein the east DeguaTenbein and Hewuzin, west Tselemti.(Kola Tenbein woreda agricultural office, 2017)

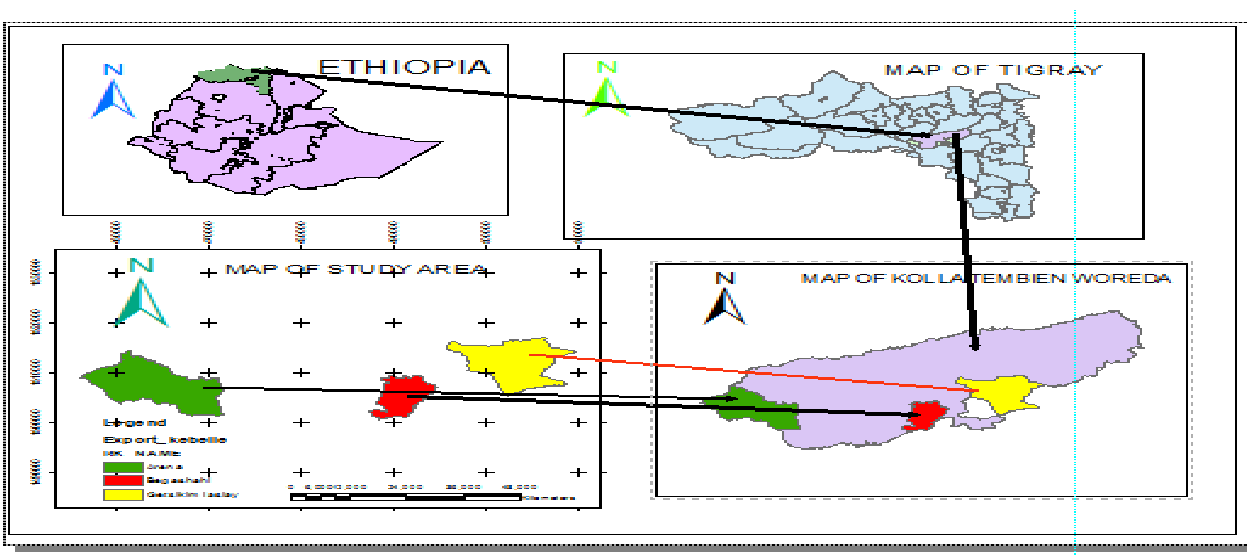

Figure: 1. Map of study area

3.1.3. Climate of study woreda

The study woreda largely receives mono-modal rainfall pattern with erratic nature. Temperature 25^{0c} to $30^{0c,}$ 350mm to 600mm average annual rainfall (Bureau of agriculture and natural resources, 2017).

3.1.4. Land use and farming system

The woreda covers an area of 136076.5ha.Farming system mixed farming i.e. traditional crop and livestock production system. (Bureau of agriculture and natural resources, 2017).

3.2.Human Population

The study woreda human population is150934 (72981male 49.4%), 74816 female 50.6%) and 32563 households (CSA, 2010).

3.3.Livestock population

The livestock population of the woreda is 199,227 from these cattle, 59146 sheep, 286245 goat, 29246 equines, 295505, poultry, and 295 camels, 18588 bee hives source (CSA, 2010).

3.4.Methodology

3.4.1. Primary Data Sources and Types

Primary data were collected from sample households using Household questionnaire, Focus group discussion, and key informants interview. Both qualitative and quantitative data were collected by these stated above techniques. Qualitative data was obtained using in-depth interviews that included group discussion and key informants' interview. Primary data were mainly related to respondents' demographic characteristics; farmers' perception on climate change. And the effect of adaptation practices on agricultural production.

3.4.2 Secondary Data Sources

Secondary data were collected from Kebelle administration offices, woreda agricultural land natural resource office, Regional Bureau of agriculture and natural resources; Meteorological Agency and other published and unpublished materials.

3.5.Sampling Techniques

For this study, multi-stage sampling procedure was followed. The study woreda were selected purposely because of three ecological zones in the selected woreda i.e. high land (Dega), mid land(weynadega) and low land (kola) and one of the crop production failures and drought in the region. Three *Kebelle* (one *Kebelle* from each agro ecological zones) were selected by random sampling.

The total sample size of the target population at 92% confidence level and 0.08 (7%) level of precision were determined by using a simplified formula provided by Yamane (1967) and reviewed by Israel, (2012);$n = \frac{N}{1+N(e)^2}$ --

Where *n* is the sample size, *N* is the population size, and *e* is the level of precision at 92% significance level. In the third stage, Probability Proportional Size (PPS) sampling technique were used to determine the number of sample households from each *Kebelle*. Finally, Begashka Kebelle house hold 1392 from these 92 household sample taken, and Kebelle Arena Kebelle household 897 from these 60 household sample taken, Getshimlesley Kebelle household 588 from these 39 sample taken total 191sample from 2877 by using a simplified formula provided by Yamane (1967) and reviewed by Israel, (2012);

Total population= 2877 = N

$$n = \frac{N}{1+N(e)^2} = \frac{2877}{1+2877(0.07)^2} = 191$$

Table.1. Household Interview Sample Size

Variables	Sampling size of house hold Interview								
	Getshimlesley		**Begashka**		**Arena**		**Total**		
	males	**females**	**males**	**females**	**males**	**females**	**males**	**females**	
HHI	**34**	**5**	**81**	**11**	**49**	**11**	**164**	**27**	191

3.6.Data collection methods

3.6.1. Household Survey

The household questionnaire was designed in line with stated objectives and research question. The semi-structured questionnaire (close-ended and open-ended questions) was generatedquantitative and qualitative data on household characteristics, demographic and educational characteristics of farmers, analyzes their perception of climate change impact and adaptation strategies 0f the study area. After setting the questionnaire a pilot test was carried out on farm households having the same socioeconomic background. To check the ease with which respondent households answer the questions, and to make sure that the questions are meaningful and also to estimate the time needed to complete one questionnaire. The questionnaire deals with respondent farm households largely addressing household headed.

3.6.2. Focus Group Discussion (FGD)

Group discussion using semi structured questions allows researchers to look into more deeply into issues and develop new lines of inquiry that arise during interviews (Denscombe, 2007). Group interviews compared to questionnaire interviews allow sensitive issues to be more freely discussed in groups when individuals would not wish to discuss them alone with a stranger (Chambers, 1992; Krueger, 1994). Taking note of the above theoretical foundations semi structured interviews were conducted to complement and compare information that was generated in the household questionnaire and interviews with key informants. In the group discussions individuals who are familiar with development activities in their localities, and those assumed to having information on the local adaptation measures against negative effects of climatic change in the study area were included. Accordingly the discussions were carried out with selected groups i.e. male headed households including Kebelle leadership; women headed households, and youth group (male and female together).

In Focus Group Discussions (FGDs) ideally group members should contain six to eight people but can be as high as 12 and if more is required needs to be supported with good reasons (Denscombe, 2007; Walker, 1985). In this study group size for discussion with rural households varied from 8 to 18 with an average of 12 participants. To increase the quality of information introductory questions were followed by key questions to the core topic and summary questions as suggested by Krueger (1998). It was attempted to make sure that a few individuals do not monopolize the conversation and do not suppress or distort the views of others, and all members were encouraged to share views (Walker, 1985). Various scholars stated that competency in moderation of the discussion is important for alleviating the problem and enhancing balanced flow of ideas (Denscombe, 2007; Walker, 1985; Patton, 1990; Kreguer, 1994, 1998).

3.6.3. Key Informants Interview (KII)

According to Kumar (1989) key informant interviews involve interviewing of knowledgeable individuals who are likely to provide the required information, ideas and insights on a particular subject. Key informant selection involves inquiring who the experts are (Chambers, 1992); hence, individual key informants were identified carefully with the help of rural households that took part in focus group discussions, Agricultural Development Agents and members of the Kebelle leadership. A total of 12 key informants (four per Kebelle) were used for the study. Efforts were made to include the elderly who have lived in the study areas for quite long period. Key informant interviews were conducted at convenient places chosen by the Key informants using a check list of open ended questions (Appendix II). The major topics discussed include information about the general of climate change (rainfall, temperature, soil fertility, forest, crop and livestock productivity, and floods); the impacts of climate change on crop production, livestock husbandry, livelihood options and various coping and adaptation strategies and climatic mitigation measures practiced at local level and the issue of their adaptability.

Table .2: Size of Respondents Sampling

VARABLES		Participant Kebelle households							
		Getshimlesley		Begashka		Arena		Total	
		male	Females	males	female	males	females	males	females
FGD	**Household**	**4**	**2**	**4**	**2**	**3**	**3**	**11**	**7**
KII	**Household**	**3**	**1**	**3**	**1**	**3**	**1**	**9**	**3**

Source: Own result,2019

Figure 2: Focus group dissection with farmers in Getshimlesley and Begashka. Source on surveys picture

3.7.Dependent variables Justification

The dependent variables included adaptation strategies adopted by the small holder farmers. The most common adaptation strategies identified during household surveys, focus group discussion and key informant interview in the respondents household.This is done to distinguish between farmers who adapted study area. A farmer is considered to have adapted to climate change if he/she has employed at least one of the adaptation strategies such as enhanced use of soil and water conservation, traditional irrigation schemes, used improved and moisture resistant crop varieties, shifting cattle's to small ruminant, implement soil and water conservation techniques, and diversifying crop varieties.

3.8.In Dependent variable Justification

The choice of independent variables used in the study area is influenced on factors that influence farmers' decisions to adaptation to climate change.

3.8.1. Gender of the respondent

Gender of the household head is hypothesized to influence the decision to adaptation to climate change. It is also asserted that women possess distinctive knowledge and skills that should be accredited and utilized to develop resilience against climate change shocks and other development activities. A recent study in South Africa by Nhemachena and Hassan (2007) reported that female-headed households are more likely to take up climate change adaptation strategy. According to the authors, the possible reason for this observation is that in most rural smallholder farming communities in the region, men more often look for jobs in towns, and much of the agricultural work is done by women.

3.8.2. Age of Respondents

Age of the head of household can be used to capture farming experience and its influence on adaptation strategy to climate change. For example Obayelu, *et al* .(2014) in their study of factors affecting farmers' choices to climate change in Nigeria reported that age has an influence on farmers efforts to adaptation to climate change. Similar views were also expressed on effect of age on improved agricultural technologies (Gbegeh and Akubuilo, 2013).

3.8.3. **Farming experience**

Farming experience is the total number of years the household head has spent making farming decisions and the variable is continuous. The more experienced the farmer is, the better informed he/she is about temperature and precipitation changes in the study areas and the more he/she is likely to employ adaptation measures that reduce the impact of climate change on his/her agricultural activities. Hassan and Nhemachena (2008) contended that it is farming experience that matters more than merely the age of the farmer when it comes to adaptation to climate change.

3.8.4. Educational level

Education as a continuous variable measured in years of formal schooling of the household head. The number of years of schooling achieved by the household head is used as a proxy for managerial input. Education plays an important role in the adoption of innovations/new technologies. Maddison (2006) argued that education diminishes the probability that no adaptation is taken. Therefore, in this study, education level of the household head is hypothesized to be positively influencing farmers' decisions to climate change adaptation.

3.8.5. Family size of the household

Household size is measured by the number of family in a household. It is assumed to represent the labor input to the farm. While Mano and Nhemachena (2006) contended that large household size is mostly inclined to divert part of its labor force into non farming activities, Hassan and Nhemachena (2008) challenged this view arguing that the opportunity cost might be too low in most small holder farming systems as off farm opportunities are difficult to find in most cases.

On the other hand Gbetibouo (2009) reported that household size enhances the farmers' adaptive capacity to respond to climate change. In this study therefore the variable is assumed to have positive or negative impacts on climate change adaptations.

3.8.6. Farm Size

Farm size helps to practice alternative crop production as a means to satisfy the needs of the family. The bigger the farm size, the more likely the farmer is to adopt suitable strategies. In this study a positive or negative relationship is expected between farm holding size and climate change adaptation.

3.8.7. Access to Extension Service

This refers to the number of contacts with extension agents that the respondent farmers made in a year. Most authors have documented positive correlation between extension contact and adoption decision of farmers (Maponya and Mpandeli, 2013; Obayelu, et al., 2014, Shongwe et al., 2014). In fact, agricultural extension is an important source of information, knowledge and advice to smallholder farmers in Ethiopia.

3.8.8. Access to credit

Access to credit service is an important factor to narrow the financial gap of the farmers so that they could purchase the required farm inputs and technologies that are useful for improving agricultural production and also to carry out income generating activities other than farming (Komba and Muchapondwa, 2015). This variable is therefore assumed to influence farmers' adaptation efforts to climate change either positively or negatively.

3.9.Methods of Data Analysis

Analyzes of meteorological data of rainfall and temperatures using the Coefficient of variation according to Hare (2003),Coefficient of variation is used to classify the degree of variability of rainfall events as less variability (CV< 20), moderate variability (20 < CV <30), and high variability (CV >30). Different software used for analyzes such as SPSS, Minitab and Microsoft excel were used for temperature and precipitation trend analysis and significant test. In rainfall analyzes a drought may be defined as a deficit of water in time and space. However, there is no general view among researchers towards a comprehensive parameterization of a drought event unfortunately due to the complex nature of the phenomenon. Several definitions of drought can be found depending on the specific way it is measured. Generally, droughts can be classified into meteorological droughts, agricultural droughts, and hydrological droughts (Dracupet al., 1980; Wilhite and Glantz, 1985). In this study, drought is considered to be a meteorological phenomenon characterized by prolonged period of abnormal precipitation deficit. Different indices are used for the identification of drought (Tate and Gustard, 2000; Keyantash and Dracup, 2002). The most commonly used meteorological drought indices are: (1) Discrete and cumulative precipitation anomalies, (2) Standardized Rainfall Anomalies (Jones and Hulme, 1996), (3) the Palmer Drought Severity Index (PDSI) (Palmer, 1965), (4) the Rainfall Anomaly Index (RAI) (van Rooy, 1965), and (5) the Standardized Precipitation Index (SPI) (McKee *etal*., 1993). In this study, we used the standardized Precipitation Index to examine the temporal characteristics of climate variability and determine the prevalence droughts over the period for the past 40 years in different agro ecology study woreda the rainfall data was calculated and computed as SPI=$\frac{xi-\overline{X}}{\sigma}$, Xi = the year rain fall, ($\overline{X}$) = mean of the year, *(σ) =standard deviation*

The standardized precipitation index (SPI) is a tool recommended and used as guide by the World meteorological Organization (McKee *et al.*, 1993; Svoboda, M *et al.* 2012)

Table: 3. the Standardized Precipitation Index (SPI) meanings

SPI value	meaning
2.0 and above	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
-0.99 to 0.99	Near normal
-1 to -1.49	Moderately dry
-1.5 to -1.99	Severely dry
-2 and less	Extremely dry

The meteorological data of rainfall and temperatures taken in Abi Adi and Hagresslam station for the past 40 years data.

The survey data was analyzed using software spss version-23 descriptive statistical tools like mean and percentage and ANOVA like statically significant different between the agro ecology.

4. RESULT AND DISCUSSION

4.1.Socio-Economic Characteristics in Study Area

4.1.1. Credit Services

Credit Service access in the study area better service in high land (82.1%) than mid land (66.3%) and low land (55%) in low land (Kola) negative impact due to lower access of credit service. It is an important factor they could purchase the required farm inputs and technologies that are useful for improving agricultural production and Climate change adaptation strategy Confirmed by key informant interview. This is agree to other source study (Komba and Muchapondwa, 2015).This variable is therefore assumed to influence farmers' adaptation efforts to climate change negatively or positive.

4.1.2. Extension Services

Access to extension services in the study area higher services in high land (79.5%) than mid land (67.4%) and low land (50%).In low land negative impact in agricultural production and climate change adaptation strategy due to lower access of extension service. In low land (Kola) affected the livelihood of small holders farmer due to lack of agricultural technologies and awareness of climate change information Confirmed by key informant interview. Other study source Most authors have documented positive correlation between extension contact and adaptation adoption decision of farmers (Maponya and Mpandeli, 2013; Obayelu, *et al.*, 2014, Shongwe*et al*., 2014).

4.1.3. Household Respondents Characteristics

In study area Sex was not a statistically significantly different (P>0.05) in different agro ecology. Overall agroecolgy of respondents household Male 86% and Female 14%, female household actively participated in climate change adaptation strategy in soil and water conservation and irrigation scheme confirmed by key informant interview. Agree from other study in South Africa by Nhemachena and Hassan (2007) reported that female-headed households are more likely to take up climate change adaptation strategy. The respondent's major occupation was 97.4 % Farming, 2.6% trading of agricultural product, the education status illiterate 47.2%, read and write 24.6%,1 up to 5 grade 13.5 %, 6 up to 8grade 9.4 % and 9 & above grade 5.3 %. Literate will a positive implication to promote agricultural technologies and adaptation to climate change confirmed by Focus group discussion. Agree from other study in their investigation of factors affecting adaptation strategies to environmental degradation and climate change at farmer's educational level in Bangladesh Uddin *et al*. (2014).

4.1.4. Age and Family Size

In the study area the household headed mean age of high land 48±1.75; mid land 47±1.2 and low land 46±1.3 in the study area most small holder farmers farming activities starting from 12 years old. The majority respondents involved more than 30 year in agriculture activity, more experienced farmers are important for agricultural production and climate change adaptation strategy confirmed by key informant's interview. Agree from other study Hassan and Nhemachena (2008) contended that it is farming experience that comes to adaptation to climate change. Also other source study farmers in Ethiopia above 10 years of age are involved in agricultural practices and related activities (CSA, 2003). The mean family size in high land (Dega) 5.5±0.14 than mid land (Wenadega) 4.58±0.12 and low land(kola) 3.55± 0.1.13 a statistically significant difference mean of family size ($p<0.05$) better labor in high land(Dega) than lowland (kola),in low land less labor power for climate change adaptation strategy and agricultural activities confirmed by focus Group discussion and key informant interview. For over all agro-ecology 4.4±0.1 family size. Contrast from other study greater than the national average 4.3 and less than the regional average 4.5 (CSA, 2010). Larger family size is expected to enable farmers to take up labor intensive adaptation measures (Nyangena, 2007; Dolisca *et al.*, 2006; Anley, 2007; Birungi, 2007). On the other hand Gbetibouo (2009) reported that household size enhances the farmers' adaptive capacity to respond to climate change.

4.1.5. Land holding and land use pattern

In study area per mean household land holding a statistically significant difference in low land (1.03 ± 0.05 ha) than in high land (0.54 ± 0.03ha) and mid land (0.78 ± 0.03ha). Farm size helps to practice alternative crop production as a means to satisfy the needs of the family. The bigger the farm size owned farmer more likely to successes adaptation strategies confirmed by focus group discussion. Traditional mixed farming commonly livestock and crop production system confirmed by Key informant interview. Other source Reviews by Samuel (2006) the agriculture in Ethiopia is practiced under the condition of diminishing farm size and a survey in the 2000 cropping season revealed that about 87.4% of rural households were holding less than 2 hectares; where as some 64.5% cultivated farms less than one hectare; while 40.6% operated land size of 0.5 hectare and less.

Table.4. Households Land Holding, Age and Family size

Agro-ecology	Descriptive statistic	Age	Family	Land holding
high land	Mean	48.05	5.49	.5385
	N	39	39	39
	Std. Error of Mean	1.752	.18	.033
mid land	Mean	47.08	4.6	.78
	N	92	92	92
	Std. Error of Mean	1.186	.123	.028
low land	Mean	46.12	3.55	1.03
	N	60	60	60
	Std. Error of Mean	1.26	.13	.049

4.2.Meteorological Data Analysis

4.2.1. Annual Rainfall Analysis in High and Low Land Agro ecology

Meteorological data analysis for the past 40 years the mean annual rainfall in high land (Dega) 0.34 times higher than low land (kola).A Statistically significant difference coefficient of variation higher in lowland (kola) than high land (Dega). Variability was higher in low land (kola), less in high land (Dega).According to (Hare, 2003). Detailed meteorological data analyzes listed below .Table.5.

Table.5. High land (Dega) and low land (Kola) Rainfall Analyzes

Variable	Numbers of years	mean	SD	CV	Se of mean	maximum	minimum
High Land	40	764.2	145	18.97	22.9	1051.0	477.1
Low Land	40	570.4	180	31.55	28.5	1108.6	253.1

4.2.2. Standardized Precipitation Index (SPI) Analysis in Low and High land

In low land (kola) the past 40 years. The dry years were occurred in 1983, 1984, 1987, 1988,1995,2000,2002, 2008 and209, longest dry years were two years. Wet years occurred in 1980, 1985, 1990, 1991, 1993and 2005, extreme wet year in 1979; the rest years were normal periods. In high land (Dega) the dry years were occurred in 1982, 1983, 1984, 1994, 1996 and 2006, longest dry years were three years. Wet year in 1978, 1986, 1991, 2008, 2009and 2012, the rest years were normal periods. More dry and extreme wet years happened in low land (kola).Analyzed by Standardized Precipitation Index (SPI). (McKee *etal.*1993). SPI is a tool recommended and used as guide by the World meteorological Organization and others Organizations.(Svoboda, M *et al*. 2012)

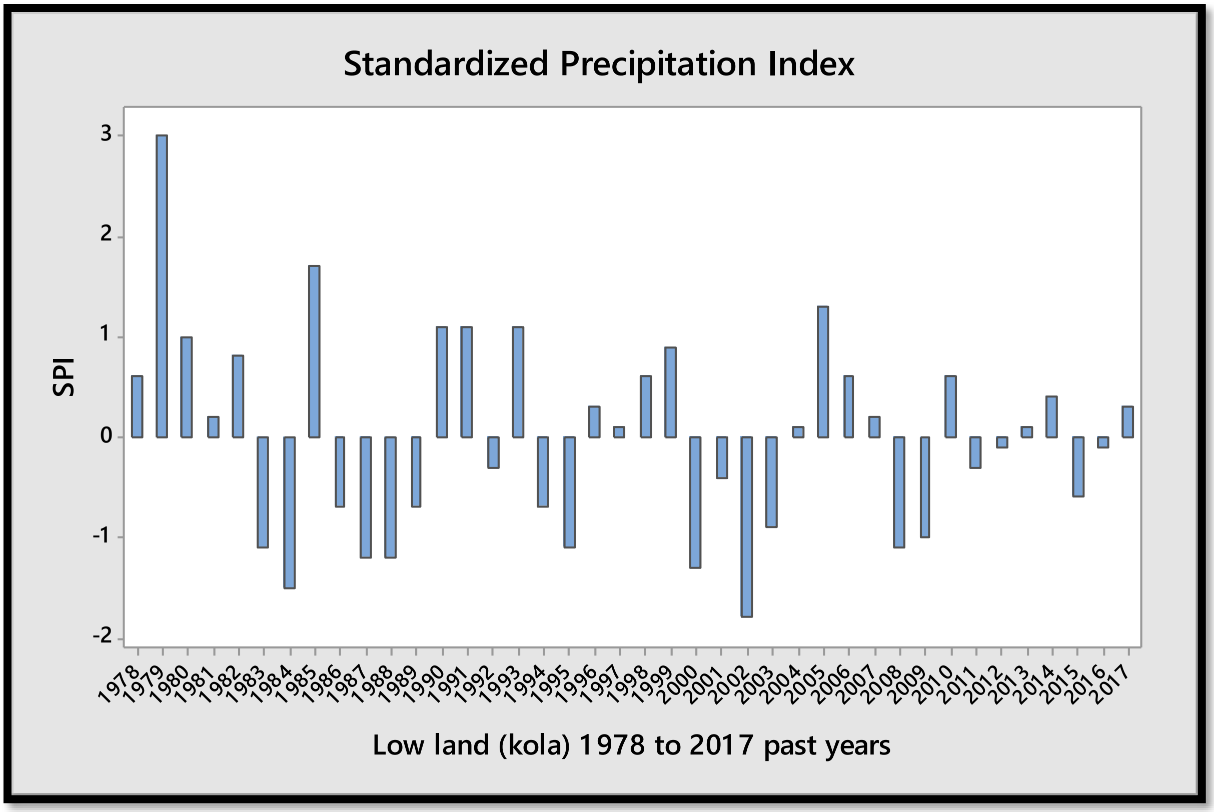

Figure.3. Low land (kola) Standardized Precipitation Index

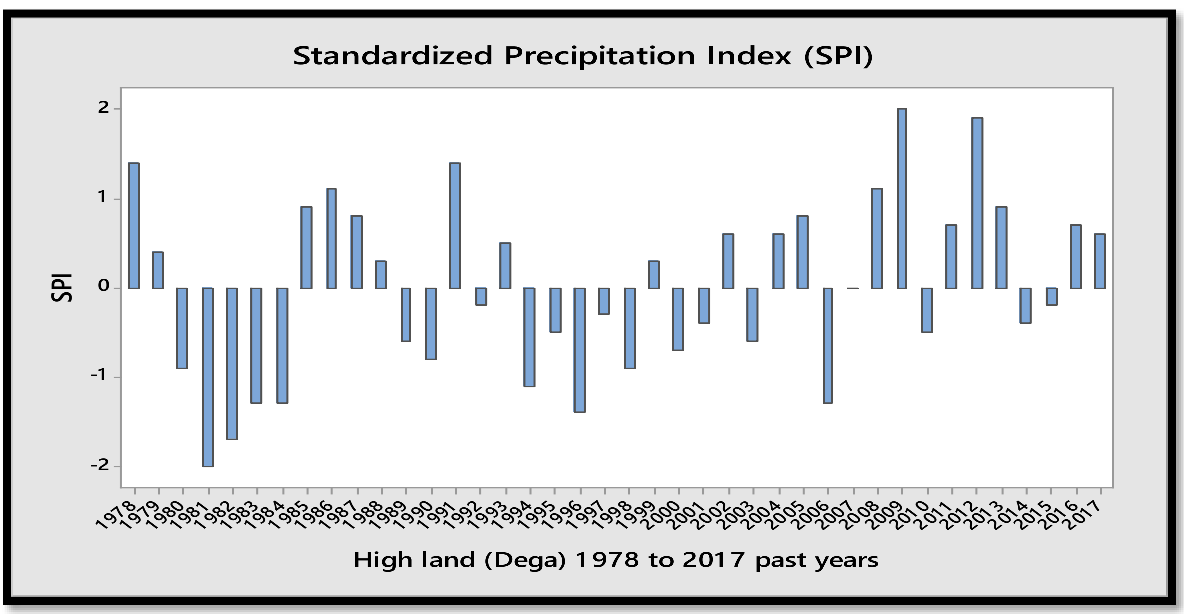

Figure.4.High land (Dega) Standardized Precipitation Index

4.2.3. Monthly Rainfall Distribution Analysis

The past 40 years of monthly rainfall distribution in high land (Dega) and low land (kola)agro ecology. In the study area the month June, July and August main rainy season, during this period a statistically significant difference of in high land (Dega) 75% than in low land (Kola) 56% from the annual rain fall is received. The months of June, July and August were more rainfall amountin high land (Dega) than low land (kola) comparatively. Detailed analyzes show below in Figure .5.

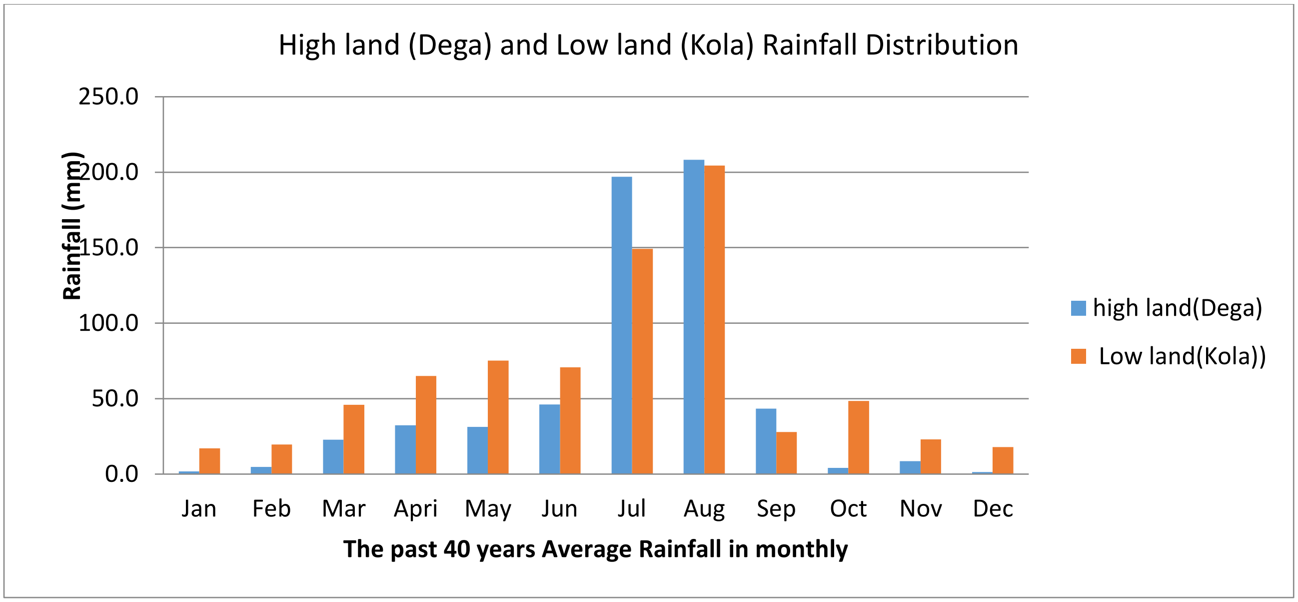

Figure.5. Monthly Rainfall Distribution

4.2.4. Monthly Rain fall Variability Analysis

In the past 40 years monthly rainfall in low and high land agroecolgy, Coefficient of variation was greater than30higher variability in all month, according to Hare (2003)in the study area climate variability affect the livelihood of small holder farmers due to frequent drought and erratic rainfall distribution confirmed by key informant interview and focus group discussion. A Statistically significant difference of coefficient of variation comparatively higher in lowland (kola) than high land (Dega).Agree to other study the average annual rainfall of the country has recently shown a very high level of Variability(NMS, 2007).Also other study Climate Change and Variability indicated the third assessment report of the international panel on Climate Change (IPCC) that developing countries are expected to suffer most from the negative impacts of climate change and variability (IPCC, 2001).Detailed rainfall data analyzes listed below

Table. 6. Monthly Analysis of Rainfall in Low land (kola)

Variable	years	Mean	SE Mean	SD	CV
Jan	40	2.12	0.74	4.7	217.6
Feb	40	5.2	1.3	8.1	156.7
Mar	40	26	3.8	24	92.2
Apr	40	37	5.4	34.2	92.5
May	40	32.8	4.8	30.5	93
Jun	40	32.4	4.3	27.4	84.3
Jul	40	204.7	13.5	85.2	41.6
Aug	40	223.3	11.9	75.3	33.7
Sep	40	43.8	8.3	52.6	120
Oct	40	6.4	2.4	15.3	237
Nov	40	6	1.95	12.2	24.3
Dec	40	1.9	0.7	4.4	236.2

Table.7.Monthly Rainfall Analysis in high land (Dega)

Variable	years	Mean	SE Mean	SD	CV
Jan	40	17	3.7	23.2	136.2
Feb	40	19.7	5.4	33.9	171.9
Mar	40	46	7.2	45.5	99
Apr	40	65	7.5	47.6	73.3
May	40	75	9.3	58.7	78.3
Jun	40	27.8	4.4	27.7	99.5
Jul	40	149.2	10.2	64.5	43.2
Aug	40	204.4	11.2	70.6	34.5
Sep	40	70.7	6.2	39.5	55.8
Oct	40	48.5	8	50.7	104.5
Nov	40	23	5	31	135.2
Dec	40	18	4.3	27.3	153.5

4.2.5. Annual Rainfall Trends

In study area mean annual rainfall graph was linear lines slope a negative value, which were used to examine the least-square regression lines i.e. annual rainfall slope equation given by Y=-2.71x+626 and R^2 0.031 in low land (kola) and y=-3.68x+839.5 and R^2 0.087 in high land (Dega). In these analyses it could be noticed that every year the data had a negative correlation coefficient, the slope of the regression line was negative in low land (kola) and high land(Dega)agro ecology respectively. Connection between the sign of the correlation coefficient and the slope of the least squares line confirmed the annual rainfall amount in the study woreda clearly showed significant variability and declining trends. Similar other study Negash et al. (2013) had investigated the spatiotemporal variability of annual rainfall over Ethiopia reported decreasing trends of annual rainfall in northern Ethiopia.

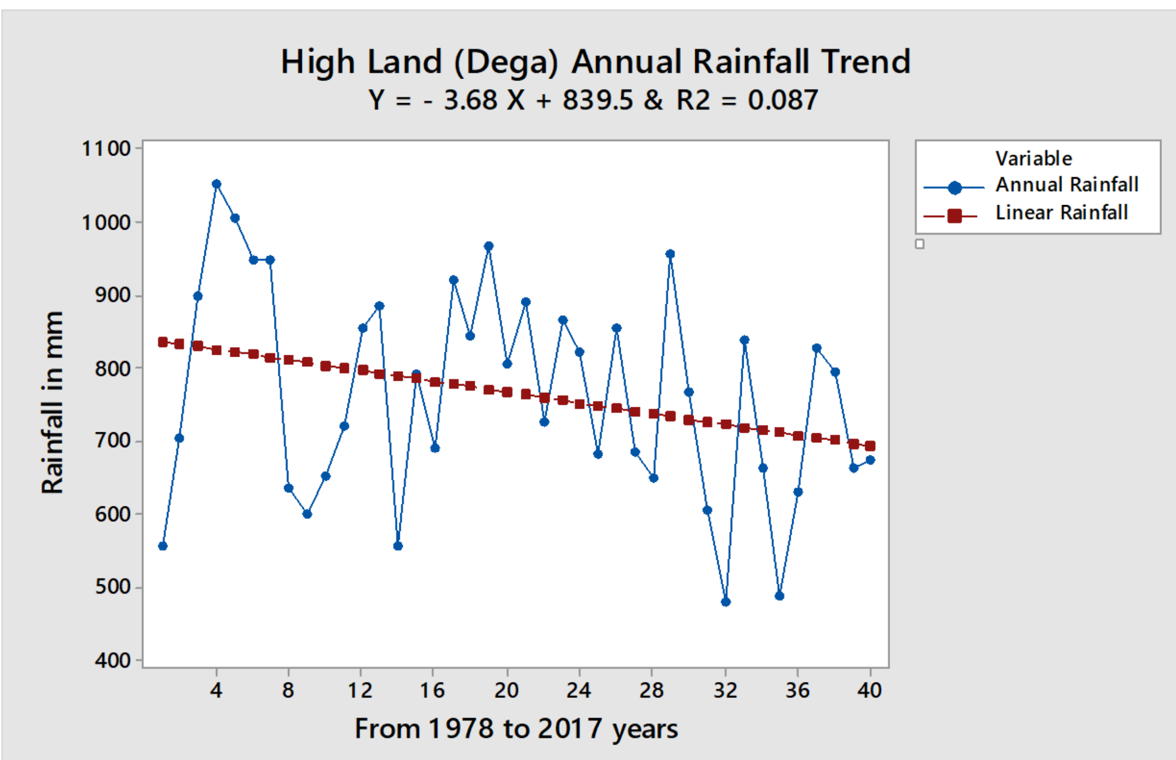

Figure.6. High land (Dega) Rainfall Trend

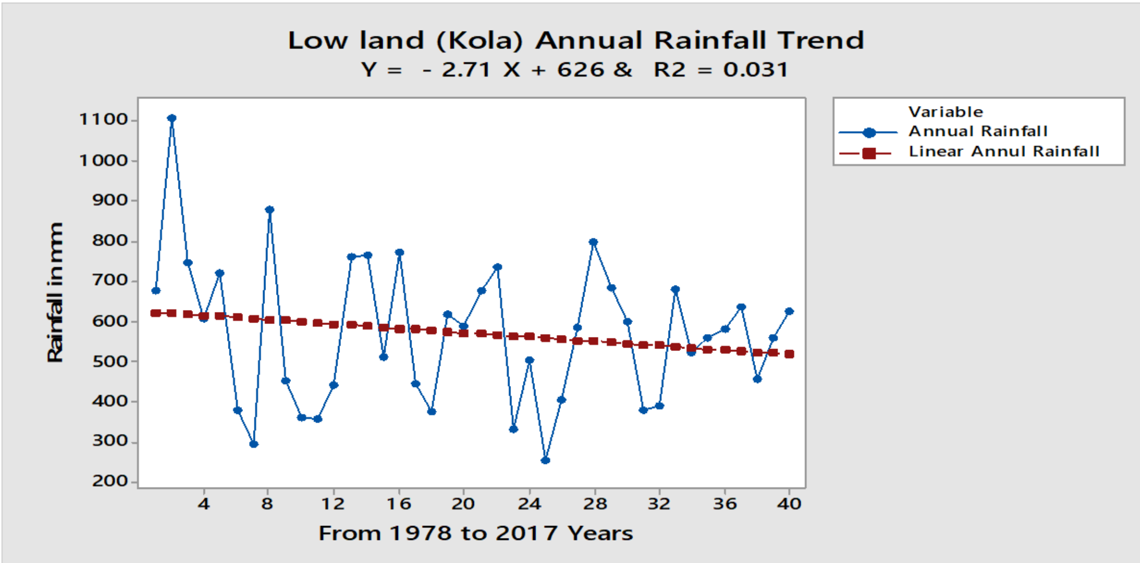

Figure.7. Low land (Kola) Annual Rainfall Trend

4.2.6. Summer (main rain) season Rainfall Trend

In study area main rainfall (summer) June, July and August linear lines in the graph was show negative slope value, which was used to examine the least-square regression linesi.e. Theslope equation given by y=-3.40x+487.2 and R^2= 0.067 in low land (kola) and y=-0.77x+397.3 and R^2 =0.006 in high land (Dega). In this analysis it could be noticed that every year the data had a negative correlation coefficient, the slope of the regression line was negative in low land (kola) and high land (Dega) agroecolgy respectively. Connection between the sign of the correlation coefficient and the slope of the least squares line and one variable confirmed the rainfall amount in the study woreda clearly showed significant variability and declining trends in main Rainfall amount the graph show below in (Figure .8&9.).More declining trend in low land (kola) than high land (Dega) due to high magnitude. In the study area due to decline rain fall amount affect crop and livestock production confirmed by focus group discussion. Similar other source Negash *et al*. (2013) had investigated the spatiotemporal variability seasonal rainfall over Ethiopia and reported decreasing trends of kiremt rainfall in northern Ethiopia.

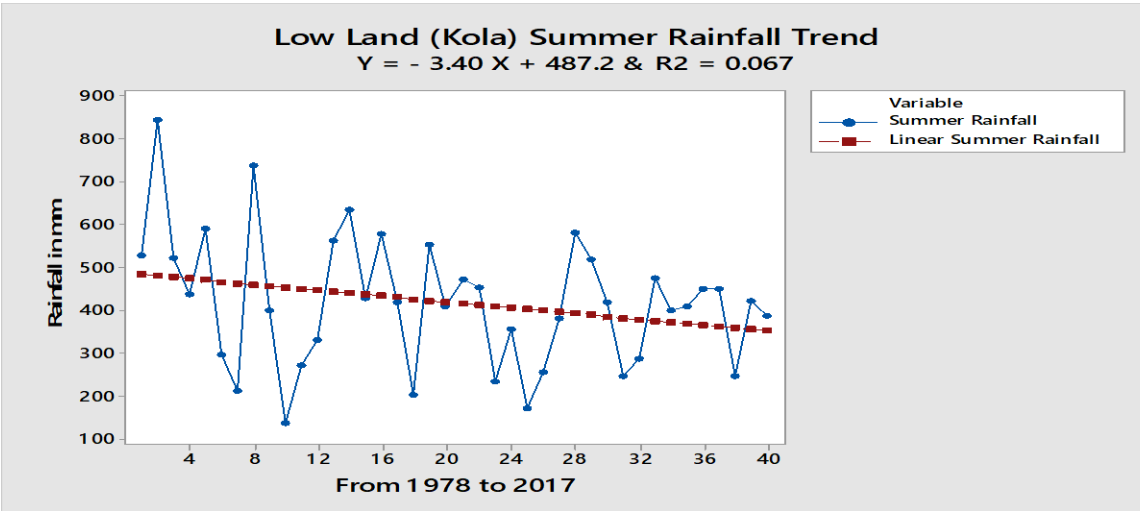

Figure.8. Low land (Kola)) Summer Rainfall Trend

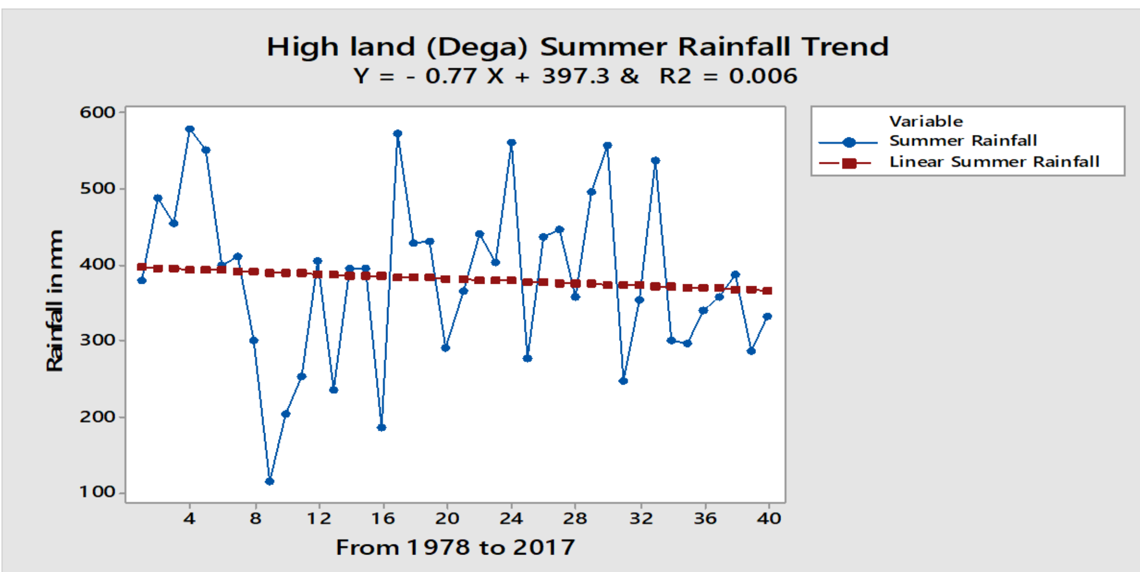

Figure.9. High land (Dega) Summer Rainfall Trend

4.2.7. Minimum and Maximum Temperature Analysis in different Agro ecology

In the study low land (kola) maximum annual mean temperature by 1.9 times more than minimum annual mean temperature. Also the coefficient of variance in minimum average

Temperature more than the maximum annual average temperature. In high land (Dega) maximum mean temperature by 2.2 times more than minimum temperature. Variability was less in high land due to lower coefficient of variance comparatively. (Hare, 2003).Detailed data listed below the table.

Table.8. Temperature Analysis in Low land

Variables	years	mean	SD	CV	min	max
Max Annual Average Temp	40	30.6	1.158	3.79	28.2	32.8
Min Annual Average Temp	40	15.9	3.77	23.7	5.1	21

Table.9. Temperature Analysis in High land

Variables	Years	Mean	SD	CV	Min	Max
Max Annual Average Temp	40	22.8	0.9	4.04	20	24.6
Min Annual Average Temp	40	10.4	0.45	4.4	9	11.2

4.2.8. Average Annual Maximum and Minimum Temperature Trend

In study area from 1978 to 2017 in low land temperature trend. The trend line shows that the average annual maximum temperature increased approximately by a factor of 0.056. This value is indicated by the positive slope equation given y= 0.056x +29.12 and the average annual minimum temperature increased approximately by a factor of 0.058. This value is indicated by the positive slope equation given y= 0.058x +13 in this positive value slope increasing temperature trend changing climate. Agree to other IfejikaSperanza (2010) and World Bank (2010) argued that Africa is expected to experience mainly negative climate change impact, in terms of an increase temperatures. From the above data the annual minimum temperature was comparatively increasing than annual maximum temperature change. Agree to other source study minimum temperature has significantly increased than maximum temperature. Evidences suggest that globally, there have been drought-inducing events, which are set to escalate in frequency and intensity in the future. (Sarah, 2002; Tebaldi et al., 2006).Detailed analyzes data show in (Figure 10&11).

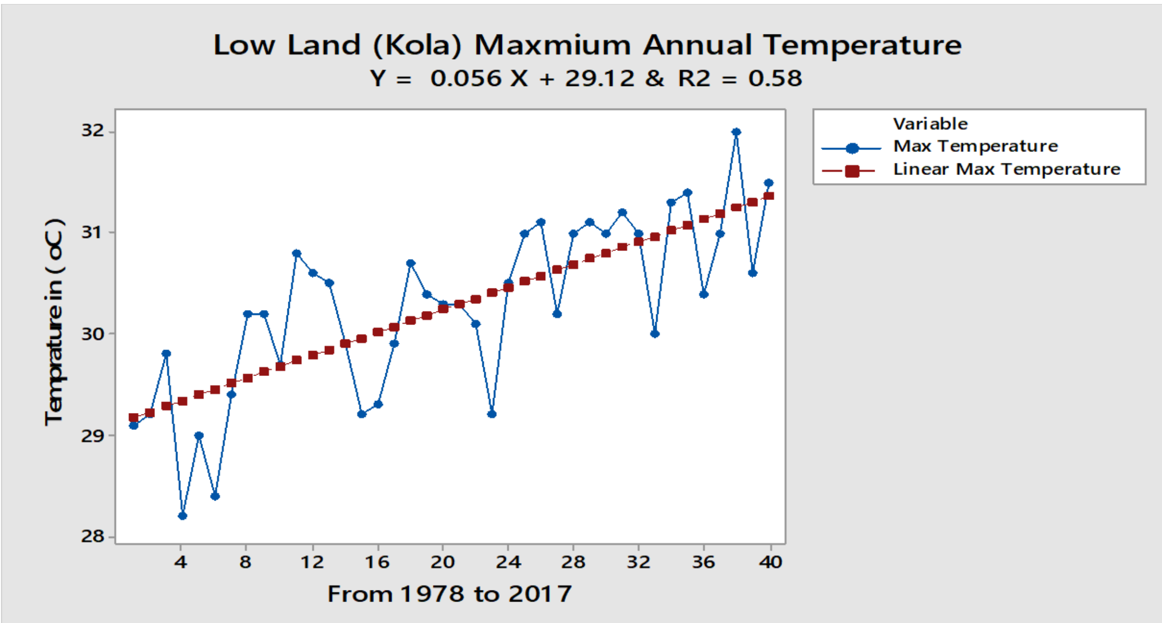

Figure.10.Average Annual Maximum Temperature Trend

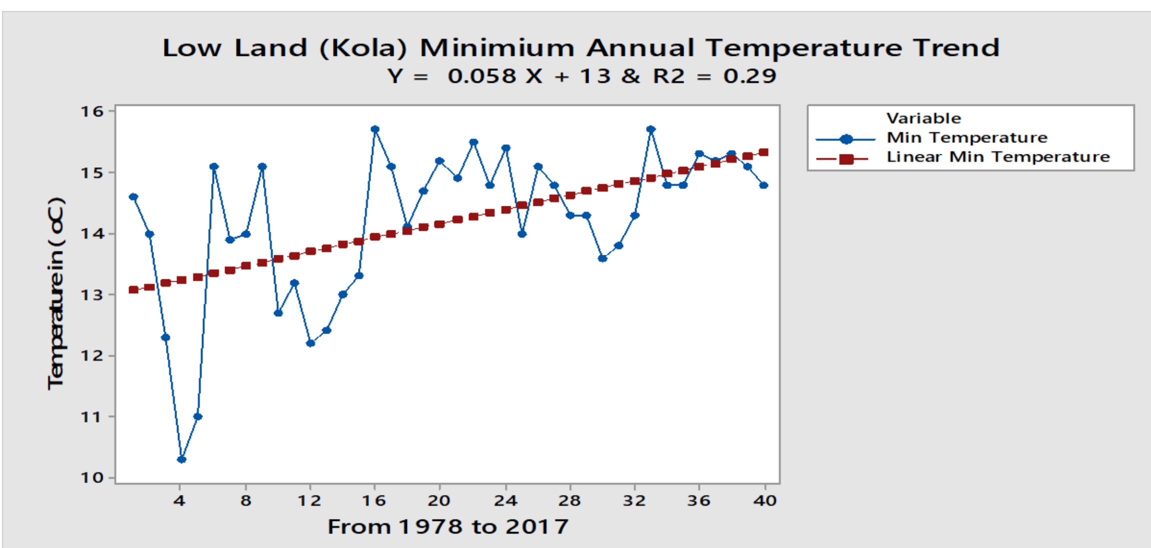

Figure.11.Low land Average Annual Minimum Temperature Trend

4.2.9. High land Maximum and minimum Annual Average Temperature Trend

In high land study area there was a general temperature change trend from 1978 to 2017. The trend line shows that the average annual maximum temperature increased approximately by a factor of 0.011. This value is indicated by the positive slope equation given y= 0.011x +22.6 andthe average annual minimum temperature increased approximately by a factor of 0.022. This value is indicated by the positive slope equation given y= 0.022x +9.9 in the graph. Annualminimum temperature has significantly increased than maximum temperature. Agree to other source study minimum temperature has significantly increased than maximum temperature. Evidences suggest that globally, there have been more drought-inducing events, which are set to escalate in frequency and intensity in the future (Sarah, 2002; Tebaldi et al., 2006).Detailed data analyzes was show in (Figure 12&13)

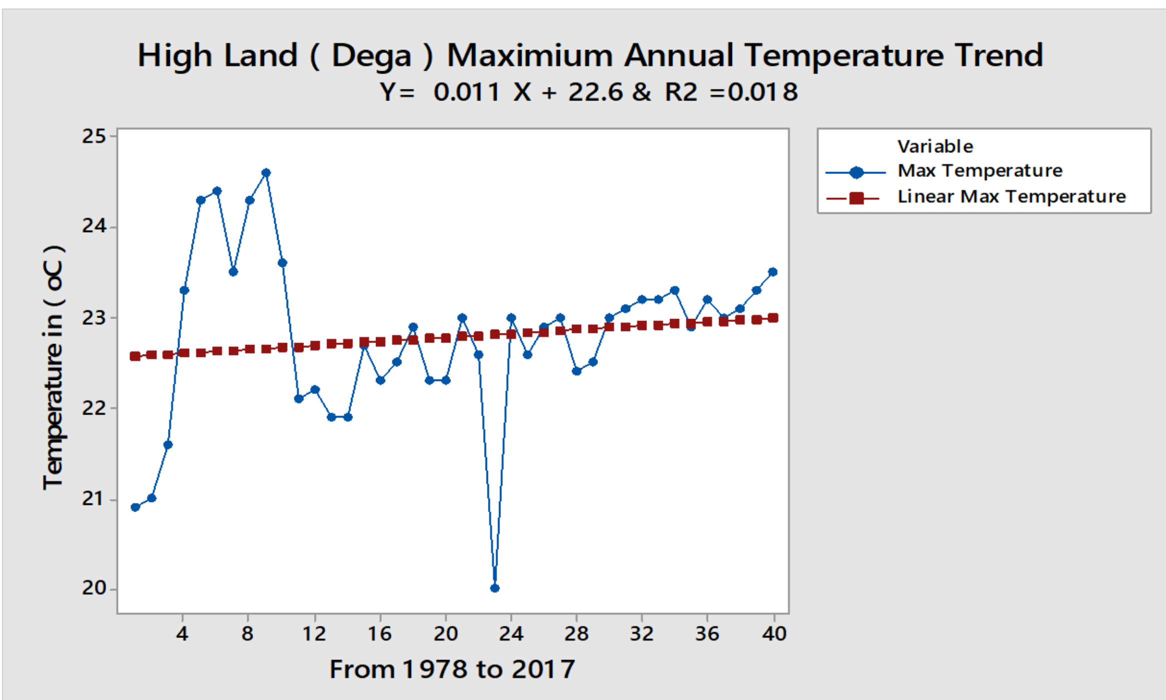

Figure.12.high land Average Annual Minimum Temperature Trend

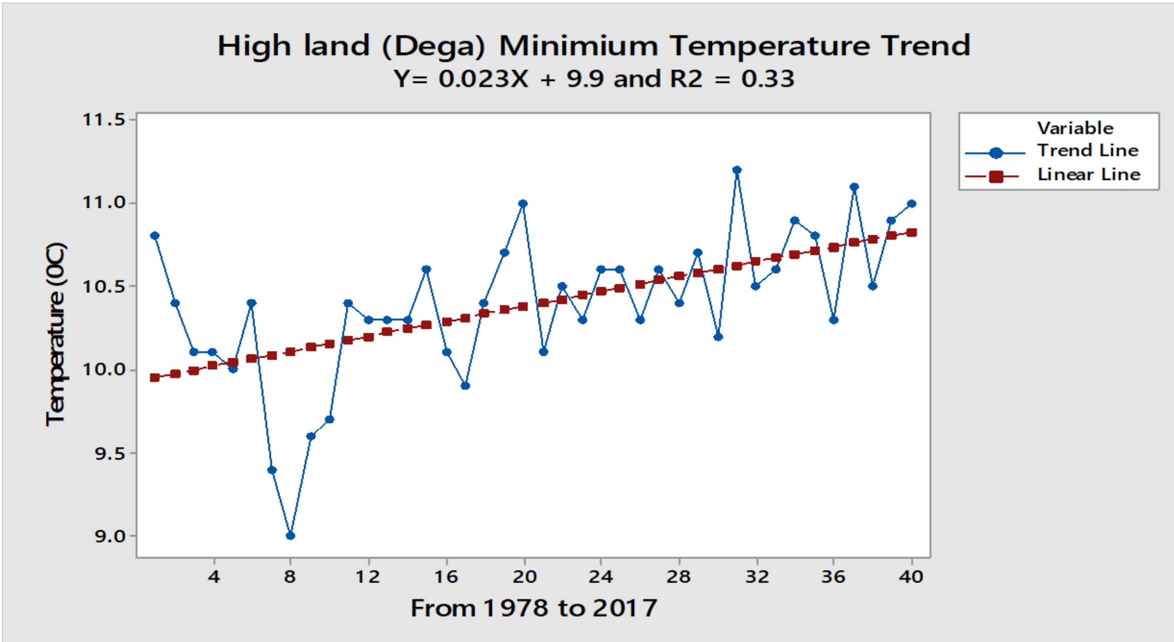

Figure.13.High land Average Annual Minimum Temperature Trend

4.2.10. High land (Dega) Minimum and Maximum Temperature monthly

The past 40 years high land(Dega) minimum temperature monthly analyzes higher mean temperature in June (14.018) and July (13.817),the lower mean temperature in December (6.856) and January (7.7). The highest coefficient of variation in December (21.8 and January (15.7). In maximum temperature monthly higher mean temperature in May (24.0) and June (24.4), the lowest temperature in November (21.2), December (20.7) and January (21.4). From the above analyzes data more variability in minimum temperature in high land (Dega).In tables.

Table.10. high land (Dega) minimum temperature monthly

Variables	years	Mean	SE Mean	Variance	SD	CV	MIN	MAX
Jan	40	7.7	0.2	1.5	1.2	15.7	4.5	10
Feb	40	8.05	0.19	1.4	1.2	14.65	5.12	9.9
Mar	40	10.2	0.16	1.1	1.04	10.2	7.5	12
Apr	40	11.3	0.1	0.42	0.7	5.7	9.9	12.7
May	40	12.2	0.09	0.3	0.54	4.4	10.9	13.3
Jun	40	14.02	0.1	0.5	0.7	4.8	12.7	15.3
Jul	40	13.82	0.31	3.82	1.95	14.14	9	23.3
Aug	40	12.84	0.08	0.3	0.53	4.11	11	13.9
Sep	40	11	0.09	0.4	0.6	5.4	9.5	12
Oct	40	8.84	0.14	0.8	0.9	9.9	7.3	11
Nov	40	8.02	0.21	1.7	1.3	16.4	5.24	11
Dec	40	6.9	0.24	2.23	1.5	218	4.5	9.8

Table.11. high land (Dega) maximum temperature monthly

Variables	years	Mean	SE Mean	Variance	SD	CV	MIN	MAX
Jan	40	21.4	0.34	4.6	2.15	10	16.2	25.5
Feb	40	22.5	0.33	4.4	2.1	9.34	17.5	27.4
Mar	40	23.5	0.23	2.14	1.5	6.23	20.02	26.8
Apr	40	23.8	0.28	3.08	1.8	7.4	19.5	28.3
May	40	24	0.22	1.9	1.4	5.7	20.02	26.4
Jun	40	24.5	0.28	3.1	1.8	7.24	20.02	27.6
Jul	40	23.21	0.23	2.2	1.5	6.4	20.02	26.6
Aug	40	22.9	0.23	2.03	1.45	6.2	19.08	26.5
Sep	40	23.5	0.21	1.8	1.33	5.7	20.2	26.95
Oct	40	22.4	0.31	3.8	1.9	8.7	19.6	32.9
Nov	40	21.2	0.2	1.3	1.13	5.33	18.1	23
Dec	40	20.7	0.23	2.04	1.4	6.9	17.7	24

4.2.11. Lowland (Kola)) Minimum and Maximum Temperature monthly

The past 40 years high land(Kola) maximum temperature monthly analyzes higher mean temperature in March (31.570) April (33.289) and May(32.620) .The lowest mean temperature in July (29,010)August (27.815) and December (29.019). In minimum temperature monthly higher mean temperature in March (15.27), April (15.68) and May (15.797), the lower temperature in December (12.779) and January (13.216).From the above analyzes data more variability in minimum temperature than maximum temperature comparatively.

Table.12. Low land Monthly Maximum Temperature

Variable	years	Mean	SE Mean	SD	Variance	CV	Min	Max
Jan	40	29.9	0.21	1.3	1.7	4.4	27.12	31.5
Feb	40	31.62	0.23	1.63	2.7	5.16	28.43	34
Mar	40	32.6	0.28	1.74	3.02	5.33	29.2	35.3
Apr	40	33.3	0.26	1.65	2.73	5	29.6	35.52
May	40	32.6	0.23	1.47	2.15	4.5	28.6	34.4
Jun	40	31.6	0.22	1.4	1.9	4.4	28.3	33.01
Jul	40	29	0.42	2.63	6.92	9.07	18	33
Aug	40	27.82	0.3	1.91	3.63	6.9	23.17	32.5
Sep	40	29.5	0.22	1.4	2	4.8	27	33
Oct	40	30.4	0.2	1.26	1.6	4.12	27.2	32.6
Nov	40	29.63	0.23	1.44	2.06	4.84	25.62	32
Dec	40	29.02	0.2	1.2	1.44	4.14	26.5	31.43

Table.13.Low land monthly Minimum Temperature

Variable	years	Mean	SE Mean	SD	Variance	CV	Min	Max
Jan	40	13.22	0.25	1.6	2.4	11.8	9.53	16.2
Feb	40	14.11	0.28	1.8	3.2	12.7	10.1	19.3
Mar	40	15.27	0.33	2.1	4.3	13.6	11.7	19.52
Apr	40	15.7	0.31	1.98	3.93	12.64	11.4	19
May	40	15.8	0.3	1.93	3.71	12.2	10.9	18.5
Jun	40	14.61	0.34	2.2	4.7	14.81	8.41	17.34
Jul	40	13.7	0.32	2.02	4.1	14.72	7.2	15.9
Aug	40	13.54	0.316	2	4	14.73	9.3	16.42
Sep	40	14.24	0.23	1.48	2.2	10.41	10	16.2
Oct	40	14.14	0.24	1.5	2.3	10.63	9.7	16.84
Nov	40	13.5	0.18	1.2	1.31	8.48	9.23	16
Dec	40	12.8	0.17	1.01	1.18	8.51	10.3	15.5

4.3. Surveying Data Analysis

4.3.1. Climate Change Indicators by Respondents

The real understanding of climate change especially temperature and rainfall by farmers were very crucial for to climate change impacts in different sectors such as agriculture and all natural resource managements. In the study area climate change indicator stated by respondents include Decline rainfall amount, increase temperature, Late on set of rainfall and early cessation of rainfall a statistically significant difference of climate change indicator ($p<0.05$) on average more stated in low land (91%) than in high land(56%) and mid land (75%). In low land climate change indicator clearly happens and affecting the livelihoods of the farmers by frequent drought and crop production failure confirmed by focus group discussions. Others source also Climate change is occurring. According to the Intergovernmental Panel on Climate change (IPCC) fourth assessment report there is ‘‘very high confidence that the global average net effect of human activities since 1750 has been one of warming’’ (IPCC, 2007, p. 3) Climate change has developed in to an issue of widespread and major concern where efforts for adaptation to changing conditions have been strongly recommended by the IPCC (2007).

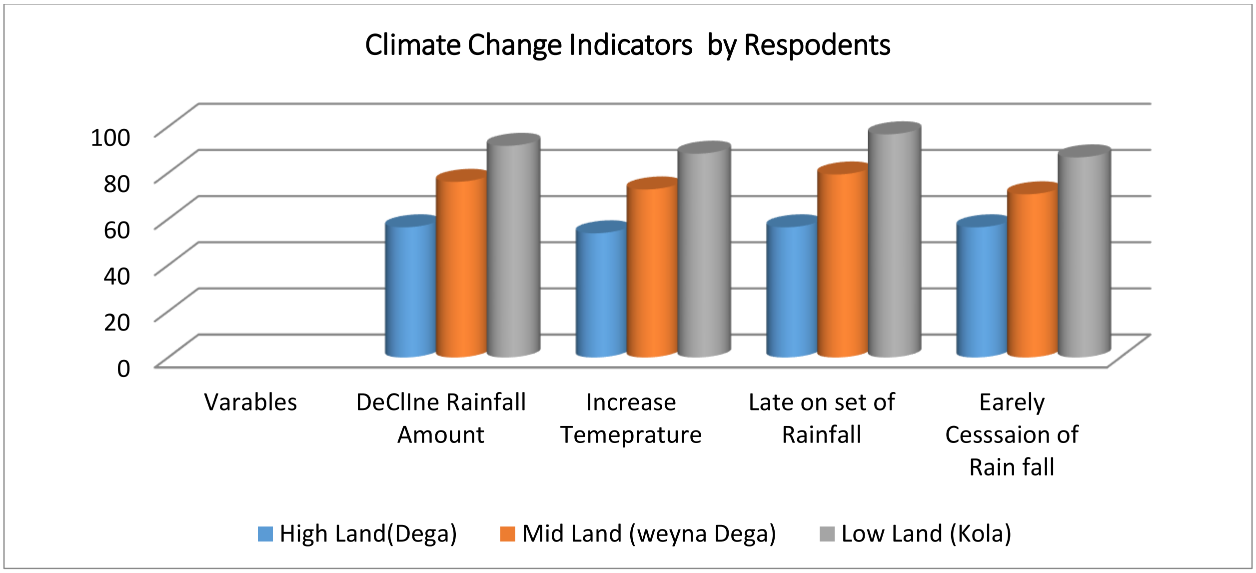

Figure. 14: Climate Change Indicators

4.3.2. Impact of Climate Change

In the study area climate change impact Stated by respondents include deceased agricultural yield, frequent drought, reduced water availability and lose some crop varieties a statistically significant difference of climate change impact ($p<0.05$) on average in low land (87%) than high land (54%) and mid land (73%). In most of the focus group discussions and key informants interview were confirmed that the climate change particularly declining and irregularity of rainfall and rising of temperature is negatively impacting agricultural productivity and livelihoods of farmers. Other similar study source climate change impact indicated frequent droughts, environmental degradation and decline in food production in Ethiopia (NMA, 2006; Aklilu& Alebachew, 2009).

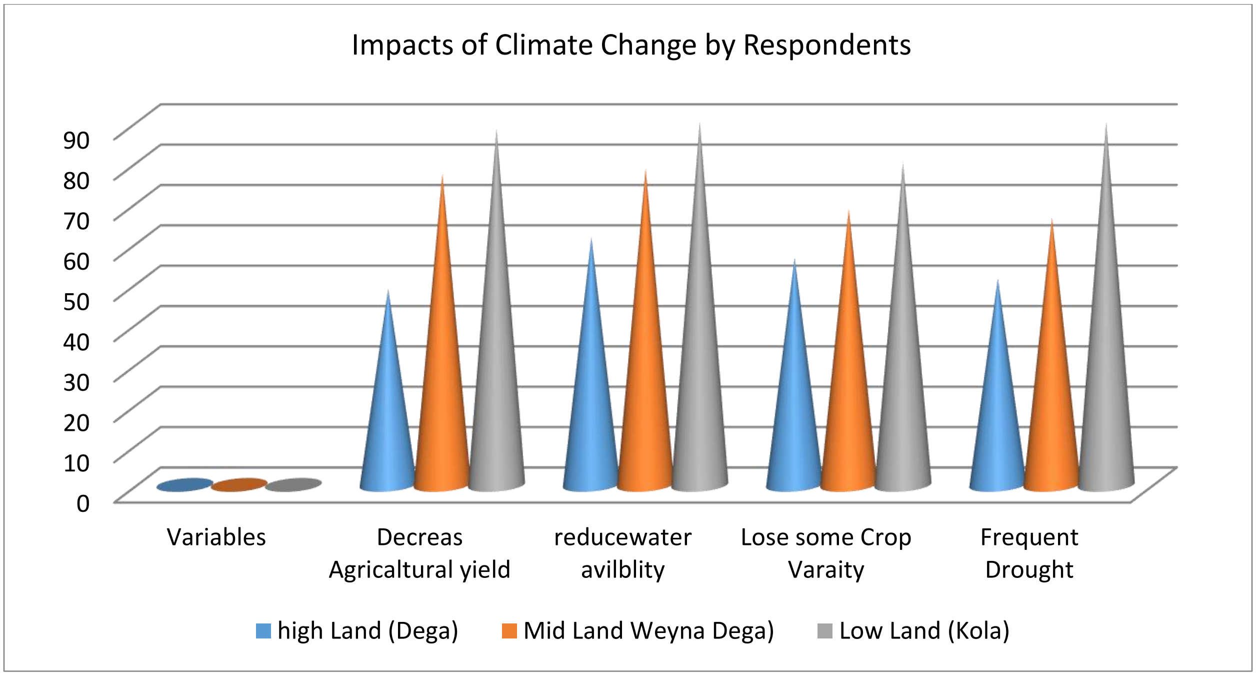

Figure.15: climate change impact

4.3.3. Climate Change Main Causes

Climate change causes as written by different previous researchers; cause of climate change had classified natural and human activities. In this study also, the most causes of climate change responded by the Household respondents include overgrazing, deforestation, population growth, Agriculture expansionon average in high land (77.6%) than mid land (73.7%) and low land (66.7%).A statistically significant difference of deforestation ($p<0.05$) more in low land(88.3) than high land (53.8%).Uses the forest for fuel wood consumption and selling for food security purpose. The impact of deforestation clearly shows in declining of rainfall amount and warming environment confirmed by Focus group discussion. Other similar study climate change caused naturally or anthropogenic causes such as deforestation, agricultural intensification, contribute to climate change (Global environmental change, 2009).

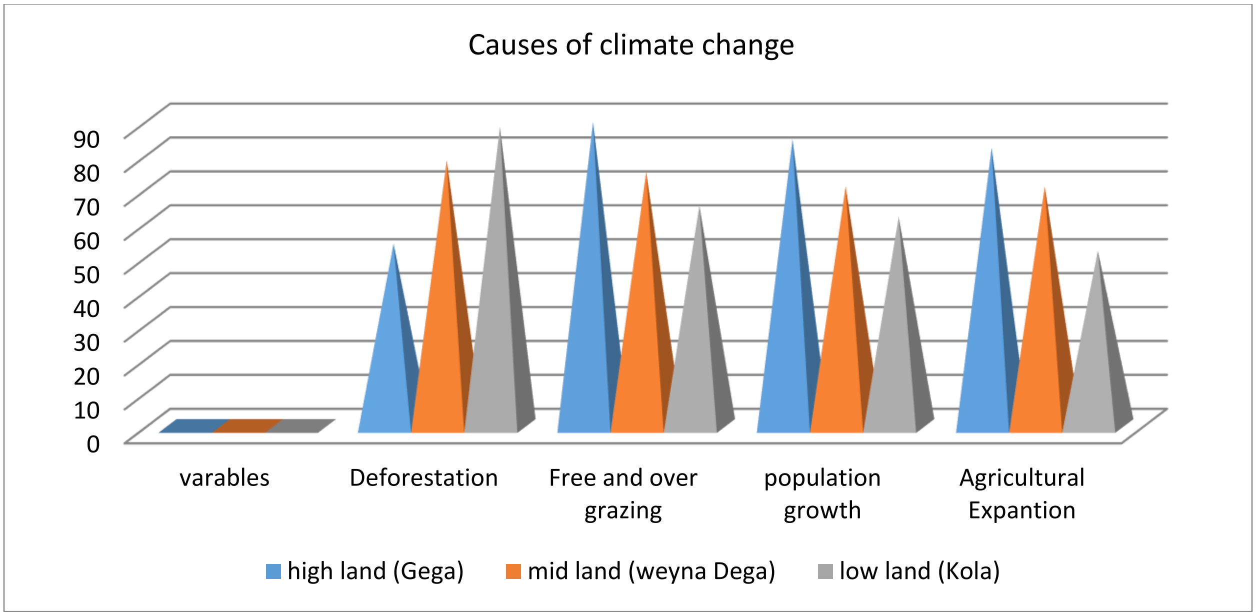

Figure.16. Causes of Climate Change

4.3.4. Climate Change Adaptation Strategy

In study area adaptation strategy to climate change is extensively recognized as a vital by farmer's response to climate change. Adaptation strategy respondents priorities include soil and water conservations, irrigation schemes, moisture stress resistant crop varieties, improved crop varieties, crop diversification and shifting cattle's to small ruminants on average a statistically significant difference of adaptation practices ($p<0.05$) in low land (82.1%) than high land (53%) and mid land (78.1%). Improved crop varieties and irrigation scheme more stated in mid latitude than low land. Stated above adaptation strategy with indigenous knowledge of small holder farmers practices regularly confirmed by key informant interview and focus group discussion. Agree from other study the most common climate variability and climate change adaptation strategy in rural Africa including Ethiopia are identified by a number of scholars (Below *et al.*, 2010; Gbetibouo, 2009; Maddison, 2006; Fosu- Mensah*et al.* 2010; Apata*et al.* 2009; Deressa*et al.* 2010; Seo and Mendelsohn 2006; Hassan and Nhemachena (2008).

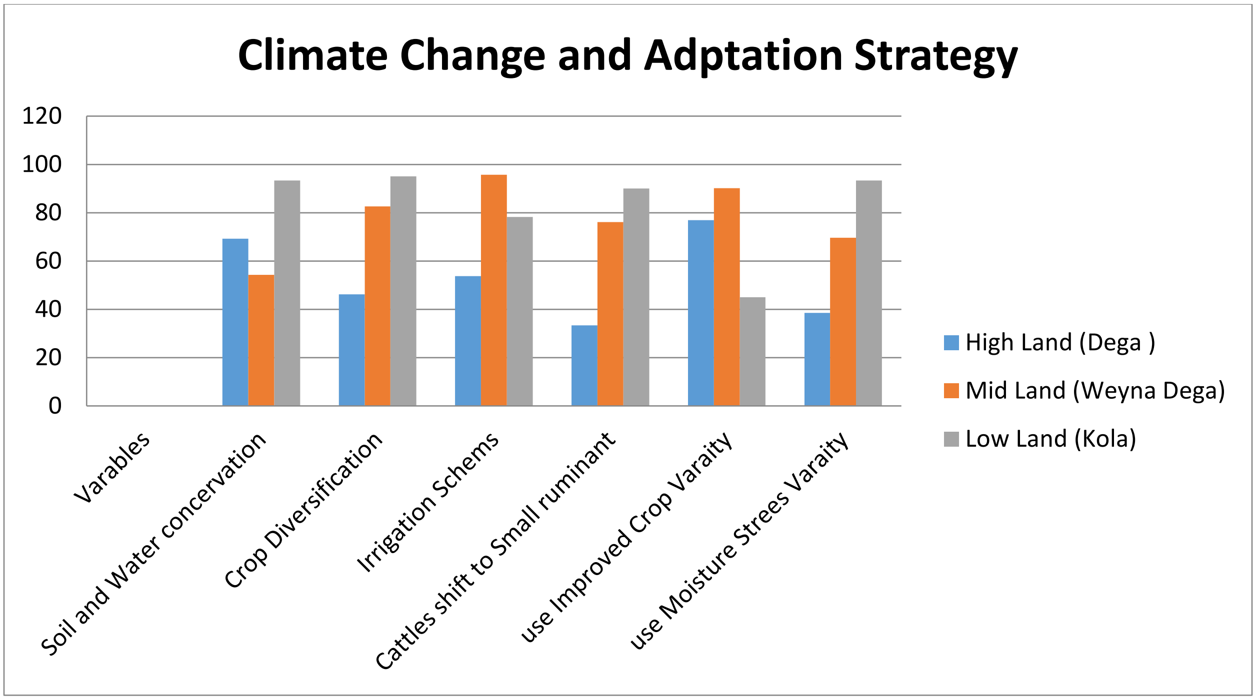

Figure.17. Climate Change Adaptation Strategy

4.3.5. Best practices in Study District

In the study woreda farmers to practices soil and water conservation done different structure without payment for 20 days yearly, with full commitment and interest for to minimize drought and others climate change impacts confirmed by focus group discussion, key informant interview. Some Soil and water conservation and irrigation strategy shown below.

Figure.18. Farmers adaptation strategy soil and water conservation and irrigation in study source surveys picture

5. CONCLUSION AND RECOMANDATION

5.1.Conclusion

The study woreda is highly dependent on the agricultural sector. Agriculture sector more correlated to rainfall and temperature. Agricultural extension and credit service significantly lower in low land (Kola) than high land negatively affect agricultural production. Meteorological data analyzes from 1978 t0 2017 years the mean annual rainfall of high land (Dega) 0.34 times higher than low land (kola).In study woreda the main rain season (summer) in June, July and August. Annual and summer rainfall amount in low land (kola) and high land (Dega) clearly showed significant variability and declining trend. In low land (kola) and high land (Dega) average annual temperature increasing fast in minimum temperature than maximum, due to fluctuation of rainfall and temperature in study woreda, there have been frequent drought. In low land (Kola) maximum temperature monthly higher mean temperature in April, May and March the lowest mean temperature in July, August and December. In High land (Dega) minimum temperature monthly higher mean temperature in June and July, the lowest mean temperature in December and January. The main causes of climate change by respondents' stated include overgrazing, deforestation, population growth, agriculture expiation. Deforestation more in low land(88.3%) than high land (53.8%). In the study woreda by surveying respondents' climate change indicator stated by respondents include decline rainfall amount, increase temperature, Late on set of rainfall and early cessation of rainfall. Climate change impacts stated by respondents include deceased agricultural yield, frequent drought, reduced water availability and lose some crop varieties a statistically significant difference of climate change impact on average in low land (87%) than high land (54%) and mid land (73%). Adaptation Strategy respondents priorities include soil and water conservations, irrigation schemes, moisture stress resistant crop varieties, improved crop varieties, crop diversification and shifting cattle's to small ruminants a statistically significant difference of adaptation strategy on average low land (82.1%) than high land (53%) and mid land (78.1%). Adaptation should be the main concern of the small holder farmers in order to counteract the negative impact of climate change.

5.2.Recommendation

To access extension services for to introduce agricultural technologies and awareness of climate change and variability information timely especially rainfall and temperature for small holders farmers in rural communities. Decrease in rainfall and increase in frequency of temperature, will have an immediate effect on the agricultural sector in order to counteract the negative impact need integration of adaptation strategy including soil and water conservation, Irrigation schemes, moisture resistant varieties and shifting cattle's to small ruminants. With development strategy in small holder farmers.

Livelihood diversification in smallholder farmers include

- Degraded lands can rehabilitate and be productive not necessarily agricultural crops but also other types of income generating scheme including different off farm activities.
- Underserved community groups can be organized into cooperatives to generate their income from rehabilitated degraded lands and
- Small holder farmer sub divide farm lands for crops, fruits, vegetables, pastures, which ripen at different time.

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APPENDIX. Survey Questionnaire for Rural Households

This questionnaire is prepared to collect data for the research proposal entitled ʻʻ Analysis of Smallholder Farmers' Perceptions of Climate Change and Adaptation Strategies to Avert Vulnerability to Climate Change: The Case of Central Zone Tenbein District Tigray Region, Ethiopia.ʼʼ The questionnaire is designed to generate data that will be used for academic purpose only. Therefore, please feel free and share us your rational views.

Location

1. Name of Kebelle ____
2. Name of Sub Kebelle/gott ____
3. District______________________ Zone _______________ Region ______________________________
4. Agro-ecology: a) Upper Highland (from 2300-3200 meters above sea level (Dega)
b) Mid Highland (from 2300-3200 meters above sea level (Weynadega)
5. Household No. ____
6. Wealth Status 1) Poor 2) medium 3) better-off/Rich
7. Date of interview ____________________

Part I: Demographic and socio-economic characteristics of the respondent household

1. Age of household head: _______________ 2. Sex of households head: 1. Male 2. Female
3. Marital status: 1). Married 2) Unmarried 3) Divorced 4) Widowed 4). Widower
4. How long have you lived in the Kebelle? ------------- Years
5. Total family size? Female:……_Male ……. Total……….

6. Literacy level of the respondent 1. Illiterate 2. Only read and write 3. Formal education (grade ---)
7. What are your occupation (list them in order of importance)

Type of occupation	Rank (1st, 2nd, 3rd, etc	1994 up to 1911 e.tc	1980 up to 1995 e.tc
Agriculture			
Trader			
trader and agriculture			
wage labor			
wage labor and agriculture			
Other (specify)			

8. What are the major challenges/problems that you face in your crop production? Please indicate them in order of
Importance

Challenges	Rank (1st, 2nd, 3rd etc.)	1994 up to 1911 e.tc	1980 up to 1995 e.tc
Moisture stress			
Soil fertility,			
Insect pest			
Weed			
others			

9. How many quintals do you produce by crop type during good rainy season on average?

Crop Type	Yield /ha in qt by 1994 to 1911 e.tc	Crop Type 1980 upto 1995 e.tc	Yield/ha in qt
Teff		Teff	
maize		maize	
Sorghum		Sorghum	
Check pea		Check pea	

PART II. Livestock Husbandry

1. How many heads of the following livestock do you have?

	Number			Number	
Livestock	1994 up to 1911 e.tc	1980 up to 1995 e.tc	Livestock	1994 up to 1911 e.tc	1980 up to 1995 e.tc
Cows			Sheep and goats		
Oxen and bulls			Equines		
Heifers			Honey bees		
Calf			Poultry		

Table 1: Questionnaire for HHs Survey

No table of figures entries found.
Do you face grazing land shortage? by comparing 1980 up to 1995 e.c and1994 up to 1911 e.c1. Yes 2. No
3. If yes during which season? 1. Dry season 2. Rainy season 3. Both
4. Do you want to keep more livestock in the future? 1. Yes 2. No

11. If yes reason/ If No reason: ……………………………………………………………………

Part III: Land Holding and Crop Production

1. What is the size of your land holding? ……….. ha. By comparing 1980 up to 1995 e.t.c and1994 up to 1911 e.t.c and why?

2. Do you feel that your land holding is adequate to produce enough for your subsistence? By comparing 1980 up to 1995 e.t.c and1994 up to 1911 e.t.c 1. Yes 2. No and why?

3. In which category do you classify your soil on basis of its fertility? 1. Low fertility 2. Medium fertile 3. Highly fertile by comparing 1980 up to 1995 e.t.c and1994 up to 1911 e.t.c and why?

PART IV: Land Use Land Cover Change Issues

1. Is there any change on the forest land/wood land area in your locality? By comparing 1980 up to 1995 e.c and1994 up to 1911 e.t.c 1. Yes 2. No and why?
1. Yes 2. No 3. Have no idea.
2. If there is change in the area of woodland is it decreasing or increasing in size? By comparing 1980 up to 1995 e.c and1994 up to 1911 e.tc 1. Yes 2. No and why? 1. Increasing 2. Decreasing 3. No change
3. Is the grazing land area cover in your locality changing in size? By comparing 1980 up to 1995 e.t.c and1994 up to 1911 e.t.c 1. Yes 2. No and why?
1. Yes 2. No

PART VI. Climate Change Perception Assessment

1. Is today's weather the same as the weather conditions that were 30 years from now?
1. Yes 2. No
2. If No, what are the major indicators?

Other		
Climatic variable	Yes	No
Rainfall amount has increased		
Rainfall amount has decreased		
Rainfall amount is the same		
Early onset of rainfall		
Late onset of rainfall		
Early cessation of rainfall		
Poor distribution of rainfall		
Frequent high volume flood		
High temperature		
Strong wind		
Other		

3. How do you evaluate the trend of the climatic variables change over the last 30 years?
1. The change has become severe 2. . Slow change
4. No visible difference has been observed 4. No change at all

5. What problems have you faced due to climatic change and variability?

Problems	yes	No	Problems	yes	no
crop failure			Increases flood disaster		
Poor livestock productivity			Loss of income		
Loss of pasture land			increase deforestation		
Loss of agricultural land			High intensity wind		
Severe soil erosion			Drying of vegetation		
Shortage of water			Drying of vegetation		

6. Which local indicators do you use to evaluate the temperature trend in the area? (Please Support your choice with example).

1. Prevalence of human and animal diseases that is not familiar to the area (malaria etc).
2. Introduction of plant and animal species that was not popular in the area (goat in Highland not common).
3. Observation of physical structures and societal clothing styles (disappearance of ice Cover in mountain peaks, frost damage become uncommon, drying up of rivers, Streams, swampy areas, lakes, dressing light cloths etc.
4. Other specify

7. What do you think is the cause of climate change?
1. Human actions 2. Natural process 3. Both human action and natural process
4. Wrath of God 5. Don't know/I have no idea
8. Have you encountered any climate related disasters after 1981? 1. Yes 2. No
9. If your answer to question No. 11 is yes, please fill the cells of the table below.
A. Year the incident happened: ……………………………………….............
B. Loss encountered in terms of crop, livestock, human lives: ……………………..
C. Coping mechanisms applied: …………………………………………………..
10. Have you ever faced food scarcity to your family? a) Yes b) No
11. If your answer is yes, in which period of years was the problems were very serious? Rank up to 3 according to severity? (1=most severe 2= medium severe 3= less sever

Period	Food security
1965-1980	
1980-1995	
1995-2010	

12. Have you ever faced water security to your livestock? 1. Yes 2. No
13. If your answer is yes, in which period of years was the problems were very serious? Rank 1 up to 3 according to severity? (1=most severe 2= medium severe 3= less sever)

Period	Food security
1965-1980	
1980-1995	
1995-2010	

Has climate change and variability created any good opportunities for you? 1. Yes 2. No
14. If Yes, Please support your answer with explanation:…………………………………..
………………………………………………………………………………………
15. Do you practice soil and water conservation on your farm land? 1. Yes 2. No
3. Don't know
16. Do you feel that such practices help you to reduce the negative impacts of climate change?
1. Yes 2. No 3. Do not know

PART VII

1.What adjustments in your farming have you made to the long-term shifts in the rainfall?
a. Enhance traditional irrigation schemes:……………… YES/NO
b. used drought resistant crop varieties: ……………….. YES?NO
c. used improved crop varieties: …………………….....YES/NO
d. shifting from crop producing to planting vegetation:…YES/NO
e. adopt crop rotation and mixed cropping:…………….. YES/NO
f. enhancing animal rearing practice : …………...……..YES/NO
g. If there are others list them ……………………………………..……………………..……………

2. Do you think the adaptive mechanism(s) you employed for the temperature problem is the best and viable one in current and future climate change and variability? 1. Yes 2. No
3. Do you think the adaptation options listed in the Table are helpful to adapt to climate change bad effects?

Adaptation Option	yes	no	Do not know	Reason
Increase use of irrigation/groundwater/watering				
Diversity from farming to non-farming Activities				
Change from livestock to crop				
Reduce number of livestock				
Change from crop to livestock Management				
Plant trees for shading				
Implement soil conservation				
Build a water harvesting scheme				
Move to different sites				
Shift planting dates				

Diversify crops				
Plant a different crop				
Change crop variety				
others				

B. Guiding questions for Focus Group Discussion (FGD) (with selected farmers representing cross section of the community, women group, youth group, Kebelle leaders

Address (location) of the Kebelle: …………………………………………………………………………………….

Focus group size: ……………………………………………………………………………………………….

Focus group composition: Male headed households/Women headed households/Youth Group, Kebelle Leaders

Checklist of questions

1. What visible changes have you observed as related to rain fall, temperature, soil fertility, forest vegetation, wildlife, crop productivity, livestock productivity, flow of streams, occurrence of big floods, incidence of drought, forest vegetation cover, river/stream flow etc during your life time in the village?
2. How often is the occurrence of drought in the locality? And what are the probable causes?
3. Have you heard of "climate change"? If yes from which sources?
4. What are your traditional or local indicators to realize that there is e climate change?
5. How is the trend of the rainfall and the temperature during the past 20 to 30 years? Is it increasing, decreasing, coming on time and stopping at the right time?
6. What coping and adaptation strategies have community members crafted to alleviate problems arising as a result of climatic variability/drought?
7. Do farmers have sufficient knowledge about Adaptation options to climate change?

8. Are the crops you cultivate now the same ash the crops your father or forefather was growing? If no, reasons for changing the crops?
9. Are the animals you are raring no the same as the animals your father or forefather used to rare? If no, reasons for changing the animals?
10. What customary self-help arrangements are there to support each other in your villages during the times of climatic extremes?
11. What effect has climate change inflicted on the livelihood of the local people?
12. Do you believe that it is possible to reduce or totally stop the negative impacts of climate change? if yes how?
13. What effect has climate change inflicted on the livelihood of the local people?
14. Can you tell us the sowing time of common grown crops some twenty-thirty years back and what time of the year do you practice seed sowing in recent years?
15. What development interventions are carried out in the village to avert the impact of climate change? (A forestation, water harvesting, irrigation, soil and water conservation, off farm employment, etc.
16. Do you agree that development interventions in the village are well planned, well discussed and undertaken after consensus or lack these attributes?
17. Do you feel that farmers are happy to participate in development activities such as soil and water conservation, forestry development without payment?
18. How do you evaluate the sustainability of development interventions promoted by government and non-government?

19. How do you evaluate the agricultural extension agents' role in motivating and mobilizing the community to strengthen their adaptive strategies to climatic changes?
20. How do you evaluate the value of tree planting to individual households' livelihood improvement and improving climate change?
21. What trainings are given to the community to reverse climatic shocks?
22. What agricultural technology and meteorological information/early warning are provided to farmers to avert climate shocks? If yes by whom?
23. Do farmers have strong organizational arrangement that could enhance local development and social cohesion? Please give your opinion.
24. What is the success stories you observed in relation to coping and adaptation strategies adopted by farmers to withstand climatic shocks?
25. What should the government and the community do to avert the impact of climate change in the Kebelle?

C. Guiding question for Key Informants in the Study Kebelles

1. What visible changes have you observed as related to rain fall, temperature, soil fertility, forest vegetation, wildlife, crop productivity, livestock productivity, flow of streams, occurrence of big floods, incidence of drought, forest vegetation cover, river/stream flow etc during your life time in the village?
2. How often is the occurrence of drought in the locality? And what are the probable causes?/How is the trend of the rainfall during the past 20 to 30 years? Is it increasing, decreasing, coming on time and stopping at the right time?
3. What coping and adaptation strategies have community members crafted to alleviate problems arising as a result of climatic variability/drought?
4. Can you tell us the sowing time of common grown crops some twenty-thirty years back and what time of the year do you practice seed sowing in recent years?
5. What effect has climate change inflicted on the livelihood of the local people?
6. What development interventions are carried out in the village to avert the impact of climate change? (A forestation, water harvesting, irrigation, soil and water conservation, off farm employment, etc.
7. Do you agree that development interventions in the village are well planned, well discussed and undertaken after consensus or lack these attributes?
8. How do you evaluate the sustainability of development interventions promoted by government and non-government?
9. Do you feel that farmers are happy to participate in development activities such as soil and water conservation, forestry development without payment?
10. How do you evaluate the agricultural extension agents' role in motivating and mobilizing the community to strengthen their adaptive strategies to climatic changes?
11. How do you evaluate the value of tree planting to individual households' livelihood improvement?

What agricultural technology and meteorology information system do you access regularly and during climatic extremes?
13. Do you receive early warning information on short term variations and/or long term climate change from any sources?
14. Do you believe that it is possible to reduce or totally stop the negative impacts of climate change? If yes how?

15. What are the successes stories you observed in relation to coping and adaptation strategies adopted by farmers to withstand climatic shocks?
16. What should the government and the community do to avert the impact of climate change in the Kebelle?