BENEFITS OF SELECTED LAND MANAGEMENT PRACTICES FOR CIMATE CHANGE ADAPTATION AT HAWASSA ZURIYA WOREDA SOUTH ETHIOPIA

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M.SC. THESIS

HAWASSA UNIVERSITY, WONDO GENET COLLEGE OF FORESTRY AND NATURAL RESOURCES, WONDO GENET, ETHIOPIA

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN CLIMATE SMART AGRICULTURAL LAND ESCAPE ASSESSEMENT

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APPROVAL SHEET-I

This is to certify that the thesis entitled **''BENEFITS OF SELECTED LAND MANAGEMENT PRACTICES FOR CIMATE CHANGE ADAPTATION in HAWASSA ZURIYA District– South Ethiopia''** is submitted in partial fulfillment of the requirements for the degree of Master of Science with specialization in **Climate Smart Agricultural Land scape Assessement**, Wondo Genet College of Forestry and Natural Resource, and is a record of original research carried out by **Bizuayehu Solomon**, Id No MSC/CSAL/006/09, under our supervision, and no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the courses of this investigation have been duly acknowledged. Therefore, we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

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Coordinator, graduate program	Signature	Date

APPROVAL SHEET-II

We, the undersigned, members of the Board of examiners of the final open defense by **BIZUAYEHU SOLOMON** have read and evaluated his thesis entitled **''BENEFITS OF SELECTED LAND MANAGEMENT PRACTICES FOR CIMATE CHANGE ADAPTATION'' in HAWASSA ZURIYA District– South Ethiopia''** and examined the candidate. This is therefore to certify that the thesis has been accepted in partial fulfillment of the requirements for the Degree of Master of Science in Climate Smart Agricltural Land Scape Assessement.

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DECLARATION

I, Bizuayehu Solomon, hereby declare that this thesis entitled ‘‘BENEFITS OF SELECTED LAND MANAGEMENT PRACTICES FOR CIMATE CHANGE ADAPTATION in HAWASSA ZURIYA District– South Ethiopia’’ submitted for the partial fulfillment of the requirements for the Masters of Science in Climate Smart agricultual land scape assessement, is the original work done by me under the supervision of Almayehu Mulneh (PhD) and this thesis has not been published or submitted elsewhere for the requirement of a degree program to the best of my knowledge and belief. Materials or ideas of other authors used in this thesis have been duly acknowledged and references are listed at the end of the main text.

Name: BIZUAYEHU SOLOMON

Signature: _______________ Date: ____________________

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LIST OF ABREVIATIONS AND ACRONYMS

AEZ	Agro Ecological Zone
BOFED	Bureau of Finance and Economic Development of SNNPRG
BOANR	Bureau of Agriculture and Natural Resources
CBPWD	Community Based Participatory Watershed Development
CEEPA	Center for Environmental Economics and Policy in Africa
CC	Climate Change
CSA	Central Statistical Authority
CSA	Climate Smart Agriculture
FGD	Focus Group Discussion
GHG	Greenhouse Gas
Ha	Hectar
HH	House Hold
HZW	Hawassa Zuriya Woreda
HZWOA	Hawassa Zuriya Woreda Office of Agriculture
IFAD	International Fund for Agricultural Development
IGA	Income Generating Activities
IPCC	Intergovernmental Panel on Climate Change
LM	Land Management
LMP	Land Management Practices
MASL	Meter above Sea Level
MANR	Ministry of Agriculture and Natural Resources

MK	Mann-Kendal
MOA	Ministry of Agriculture
MOARD	Ministry of Agriculture and rural development
NMA	National Meteorological Agency
PCI	Precipitation Concentration Index
QT	Quintal
SLM	Sustainable Land Management
SLMP	Sustainable Land Management Project
SNNPS	Southern Nations Nationalities and Peoples State
SPSS	Statistical Package for Social Science
SRA	Standardized Rainfall Anomaly
SSA	Sub Saharan Africa
SRES	Special Report on Emissions Scenarios
SWC	Soil and Water Conservation
Tmin	Minimum Temperature
Tmax	Maximum Temperature

BENEFITS OF SELECTED LAND MANAGEMENT PRACTICES FOR CIMATE CHANGE ADAPTATION AT HAWASSA ZURIYA WOREDA SOUTH ETHIOPIA

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Abstract

There is nothing comparable to land that provides basis for livelihood in Ethiopia. Land therefore is the main stay of the Ethiopian people. This resources were degrading and shrinking due to wanton use. This coupled with anthropogenic climate change has worsen the problems at hand. Agriculture is a fundamental human activity at risk from climate change in the coming decade. The study analyzes the trends of climate change and benefits of land management practices as a climate change adaptation mechanism in Hawassa zuriya district of SNNPRS. The objectives were to analyze climate change trends of the area, inventory of land management practices of respondents and evaluate the benefits of land management practices as a climate change adaptation measure. A study of this nature will help both farmers and scholars as it outlines various practices that could help farmers adapt. Data were collected using semi structured questionnaire from 126 randomly selected HHs and oral interviews (KII and FGD) to capture stakeholder opinions. Mann-Kendal test was employed for climate data and descriptive tools of analysis such as frequency counts and ranking presented in tabular and graphical forms were used to analyze the collected data. The results showed that the annual rainfall varied between 670.9 and 1197.9 mm with a coefficient of variation of 15% and mean 953.5 mm. More over the study also found significant increase in minimum as well as maximum temperature and insignificant decrease in annual rainfall. Respondents practice mulching, composting, agro-forestry, irrigation and conservation/minimum tillage on their farm with direct benefits in yield increment, reduced erosion and crop failure as well as an increase in income. This implies that with enhanced temperature stress and reduced rain fall, land management practices can contribute to make farming systems of the rural poor farmers more resilient to the adverse effects of climate change. Therefore, there is a need to expand those LMP and maintain them to meet their intended goal. To accomplish this, the result suggests water harvesting, family planning, strengthening institutional capacity of early warning, education and training must be extended regularly to all farmers.

1. INTRODUCTION

1.1 Background

The livelihoods and security of food of the small-scale farmers of SSA are specially threatened by climate change (including increasing recurrence of extreme weather events and variability) as it is already having direct impacts on agricultural production and productivity (TerrAfrica, 2009). The change in climate could cause serious deterioration of rural livelihoods and increase food insecurity in SSA (TerrAfrica, 2009). Given these multiple challenges, the region's small-scale farmers and pastoralists must adapt, in particular by adopting technologies to increase the productivity, the stability and the resilience of their production systems(TerrAfrica, 2009).

There is nothing comparable to land that provides basis for livelihood in Ethiopia. Land therefore is the main stay of the Ethiopian people. At the beginning of the last century land and its resources were abundant to the people who want to use it. However, as the population density increased now and again in the last 5 decades and afterwards, the resources were degrading and shrinking due to wanton use (MOA, 2014). As a result they are now below the demands of the people. The result was reflected by shortage of food, feed, and wood for different uses and land for cultivation and grazing per each household. This coupled with anthropogenic climate change has worsen the problems at hand . Agriculture is a fundamental human activity at risk from climate change in the coming decades (Tubiello, et al., 2008). At the same time it will continue to be, a major driver of environmental and climate change at local, regional and global scales. Sympathetic to the problem as a result of extreme events in the last decades the Ethiopian government as well as many other organizations have been exerted lots of efforts in order to reverse the situation. The land management practices by the SLMP project is among those efforts. The project strives to conserve the environment and plays a greater role in sustainable economic growth and development. The issue of climate change stands at the heart of this effort. Currently the issue of climate is one of the key agenda worldwide. Ethiopia is highly vulnerable to climate change and low capacity to adapt and perceived climate change is a natural phenomenon which influences agricultural production and negative effect on the social and economic activities and lead to food insecurity in particular (MoFED, 2010). According to Reij and Steeds (2003), improved land management leads to higher crop yields, farmers can achieve and reap more benefits by leaving strips of natural vegetation to terrace the slopes; the strips enrich the soils. In addition, Scherr and Sthapit (2009) opines that improved land management does not only enriches the landscapes and enhances food security but also helps to "cool" the earth by cutting greenhouse gas emissions and storing carbon in soils and vegetation. Blaikie and Brookfield (1987) observed that land and water degradation may be unintentional and unperceived; it may result from carelessness or from the unavoidable struggle of vulnerable populations for the necessities of survival. On the other hand, in the past four decades, since 1960s, scientific advances and application of improved knowledge and technologies by some farmers have resulted in significant total and per capita food increases, reduced food prices and the sparing of new land that otherwise would have been needed to achieve the same level of production (Evenson & Gollin, 2003 as cited in Bewket 2010).

According to Fischer et al. (2005), most climate model scenarios agree that most African **cou**ntries including Ethiopia are expected to drop cereal production potential by the 2080s.Those countries account for 45 percent of the total number of undernourished people in sub-Sahara Africa, or 87 million undernourished people. Climate change and variations tend to disproportionately affect livelihoods of the rural poor as a result of their reduced capacity to buffer against climate risk through assets or the financial market (Brown et al. 2008). Therefore, appropriate adaptation measures targeted at this group should be a priority. Proper land management measures are among the important approaches that households can use to adapt to climate vulnerability and change. Ethiopia consider soil and water conservation techniques as key strategy to adapt to global warming (Deressa, 2008). Proper LM measures can also help to mitigate GHG emissions and climate change by sequestering carbon in the soil and vegetation, or by reducing emissions of carbon dioxide, nitrous oxide or methane caused by poor land management practices. However, climate change adaptation strategies that do not involve proper land management approaches, such as land expansion into forest areas or excessive crop input applications, including pesticides, might exacerbate land degradation and contribute to GHG emissions. While these strategies have been instrumental for farmers' survival, they have also contributed to increased deforestation, soil nutrient depletion, soil erosion and reduced water retention. Therefore, by increasing environmental degradation, short-term adaptation strategies adopted to cope with current climate changes might increase the vulnerability of the population to future impacts of climate change. As part of land management practice, Ethiopia has conducted a very huge Watershed development activities in the last four decades in response to recurring drought , famine and serious land degradation with many objectives. According to Lakew.et al.(2005), the objective of watershed management is to improve the livelihoods of rural communities and households through (i) SWC for productive uses; (ii) rainwater harvesting for improved ground water recharge; (iii) promoting sustainable farming systems and agricultural productivity adopting suitable soil, water, nutrient and crop management practices; (iv) rehabilitating and reclaiming marginal lands through appropriate conservation measures, such as planting of trees, shrubs and grasses depending on existing potential; and (v) enhancing the income of smallholders by diversifying agricultural practices and income-generating activities (IGAs). In general, proper land management creates opportunities for reclaiming degraded land, improving soil fertility, water resources development, increasing agricultural production, off-farm activities, diversifying income sources and providing access to markets, where the benefits are realized at household and community level and hence ultimately increases adaptive capacity of small holders for the changing climate.

Like many other parts of Ethiopia the HZ district has experienced drought, flood and many other problems as a result of change in climate. Six years ago the Hawassa zuriya watershed were delineated, and participatory watershed development plan were prepared and many LM practices has been introduced and implemented by the SLMP. However the benefits of those LMP for climate change adaptation has not been assessed and documented. It is therefore critical to examine the benefits for LM approaches to help adapt to climate change in SNNP in general and at Hawasa zuriya woreda in particular.

1.2 Statement of the Problem

Ethiopian economy largely depends on agriculture and like other parts of the world has been experiencing pronounced climatic changes in the last four decades. As indicated by FAO (2005) extreme events, such as increased frequency and intensity of droughts will have much more serious consequences for chronic and transitory food insecurity than will shifts in the patterns of average temperature and precipitation. Historically, climate extremes, especially higher temperature and variability of rain fall, are not a new phenomenon in Ethiopia. Most part of the country is prone to climatic extremes (NMA, 2007). Even though there has been a long history of those events and their effects, studies show that their frequency has increased over the past few decades, especially in the lowlands (Bewket, 20100). Recurrent drought events in the past have resulted in huge loss of productivity, land degradation, loss of life and property as well as migration of people (FAO,2005). For instance, the 1973-1974, 1983/1984, 2000/2003 climatic change caused drought and resulted famines that affected millions of people and claimed thousands of lives to death (NMA, 2007). The deaths in all these years were not due to overheat stress rather chronic food insecurity resulted from massive crop failure, livestock deaths and water scarcity (NMA, 2007). The other climate related hazards that affect Ethiopia from time to time are flash and seasonal river floods (NMA,2007). Major floods which caused loss of life and property occurred in different parts of the country in 1988, 1993, 1994, 1995, 1996 and 2006 (NMA,2007). For example, the 2006 floods of Dire Dawa and Omo brought many tolls including losses of human and livestock lives, crops, and biodiversity. Agricultural production and food security (including access to food) of smallholder farmers are likely to be severely compromised by climate change and climate variability in Ethiopia. Research reports indicated that both decline in precipitation and increase in temperature are damaging and will continue to damage the Ethiopian agriculture sector (Temesgen, et al., 2008a). The findings indicated that climate change reduces the net revenue per hectare both by 2050 and 2100 under all scenarios form SRES models. According to the enquiry the damage that climate change causes to the welfare of Ethiopian farmers continues to increase over years, affecting the different AEZs differently. Vulnerability to climate change in Ethiopia is highly related with poverty (loss of coping or adaptive capacity) (Temesgen, et al., 2008a). Hence, Climatic shocks render an already vulnerable population susceptible to livelihood crises. Finally, the studies suggested for adaptation practices as the calculated damages are so severe that the survival of the Ethiopian agriculture sector itself will be at stake. Hawassa zuriya woreda farming community in Sidama zone, like farmers in any other part of Ethiopia, is suffering from climate upheavals which have become common natural disasters in the country. First, there has been more erratic rainfall in the seasons, bringing drought and reduction in crop yields and plant varieties; the rainfall especially in the later rains towards the end of the year (July and August) has been reported as coming in more intense and destructive downpours, bringing floods and soil erosion. Second, there has been an increase in temperature which disturbs the physiology of crops, the micro-climate, and the soil system on which they grow. Third, the crop and livestock production has been recurrently hit by droughts, and floods. Fourth, annual runoff and water availability has been reported to decrease dramatically. Food insecurity in the area is a major challenge and all these climate shocks have exacerbated the negative impacts on food security of poorer farm households as they have the lowest capacity to adapt to changes in climatic conditions (HZWOA, 2014). Since Hawassa zuriya woreda's agriculture is mostly rain fed, the pattern of food production has been threatened and rapidly tending towards food insecurity as explained in BOA, (2014) report. Climate change and food insecurity have negatively affected livelihood of smallholder farmers in the area. However, farmers in the woreda have adapted to different land management practices introduced by SLMP to counter the effects of changing climatic patterns. However, there has been little research done on evaluation of the benefits of those LMP for climate change adaptation in SNNP in general and Hawassa zuriya woreda in particular. The issues of land management practices and their benefits for climate change adaptation need to be addressed and documented. Therefore this research is necessary to fill this information gap.

1.3 OBJECTIVES

1.3.1 General objective

- To explore the climate trend and benefits of land management practices for climate change adaptation in the study area.

1.3.2 The specific objectives are

- To describe the trends of climate change and variability in the study area for 30 years (1987-2016)
- To identify and describe on farm land management practices in the study area
- To ascertain the benefits of land management practices for climate change adaptation (crop productivity and income).

1.4 Research questions

1) What are the climate change trends in the study area?

2) What land management practices are in the study area? who introduced these practices (government ,SLMP, other organizations or indigenous) for climate change adaptation;?

3) Which practices are particularly important for climate change adaptation

5) What are the effects as a result of selected land management practices for climate change adaptation (on crop productivity and income after LMP).

1.6 Significance of the study

In Ethiopia the responsible officers are unable to continuously and consistently follow the benefits of the land management practices for climate change adaptation. Scientists say that adoption of these technologies by farmers has been slow and often the targeted number has not been reached (Mucheru et al., 2002 as cited in Bewket, 2010). This has necessitated this study on evaluation of land management to enhance adaptive capacity, a case study of Hawassa zuriya woreda. It is hoped that this study will yield data and information that will be useful for proper planning and decision making for the key policy makers such as the Government ministries, Bureau of Agriculture, Bureau of Environment and forest, among other Bureaus, donor agencies and other international organizations for the management actions for the change and development of the internally efficient farmers capacity on ways to curb adverse effects of climate change yields for entire Ethiopia. The study is also expected to improve promotion and adoption of practices and be useful to extension of knowledge because it will highlight on suitable low cost land management practice to enhance adaptive capacity. The researcher hopes that the study will form a basis for further research on comprehensive importance of the remaining land management practices from Hawassa zuriya woreda as strategy to monitor on the benefits of LMP practices for climate change adaptation. This could lead to the generation of new ideas for the better and more efficient, land management practices to the farmers, and other related land users.

2. Literature Review

2.1. Basic Terms and Definitions

2.1.1. Climate vs. climate change

Climate is simply the weather that is dominant or normal in a particular region; which includes temperature patterns of precipitation and wind (FAO,2014) . According to James (2008) topography, global air and ocean currents, vegetation cover, global temperatures and other factors influence the climate of an area, which causes the local weather. IPCC (2007) also defined climate change as any change in climate over time, whether due to natural variability or anthropogenic activity. It refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for longer period (typically decades or longer). Climate change may be due to natural processes or external forcing, or to persistent human induced changes in the atmospheric composition or in land-use (IPCC, 2007).

2.1.2. Climate change response as per the farmers view

Perception is more complex process by which people select, organize and interpret sensory stimulation into meaningful and coherent picture of the world (Berelson and Steiner, 1964). Consequently farmers learn and adopt new technologies in different ways. Farmers tend to reverse and try to adapt to the adverse effects of weather changes based on their perception and observations from neighbors, success stories and practices.

2.1.3. Adaptation to climate change

Adaptation to climate change refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts (IPCC, 2001) .

It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change.

2.1.4. Adaptive capacity

The ability of a household to resist or adjust to climate change (encompassing climate variability and extremes), to minimize potential damages, to use advantage of opportunities of the consequences (IPCC, 2007).

Adaptive capacity refers to the potential of individuals and societies to respond to change" (IPCC, 2007). Adaptive capacity represents the set of both biophysical and socio-economic factors that determine people's ability to cope with stress or change in terms of the likelihood of occurrence and impacts of weather and climate related events (Nicholls et al., 1999).

2.1.5 Adaptive strategy:

A strategy that allows people to respond to a set of evolving conditions (biophysical, social and economic) that they have not previously experienced. The extent to which communities are able to respond successfully to a new set of circumstances depends upon their adaptive capacity. For example the following are some (IPCC, 2007)

Agro-forestry:

AF is a dynamic ecologically based natural resources management system that through integration of trees on farms and in the agricultural landscape diversifies and sustains production for increased economic, social and environmental benefits (Leakey, 1997).

Conservation agriculture (CA):

Conservation agriculture is an approach to managing agro-ecosystems for improved and sustained productivity, characterized by three linked principles: continuous minimum mechanical soil disturbance; permanent organic soil cover; and diversification of crop species grown in sequences and/or associations (FAO, 2013).

2.1.6 Coping capacity:

The ability of people, organizations and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters.

2.1.7 OTHERS

Hazard: A dangerous phenomenon, substance, human activity or condition that causes loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (TerrAfrica, 2009).

Resilience: The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner (TerrAfrica, 2009).

Risk: The combination of the probability of an event and its negative consequences.

Sensitivity (to climate variability or change): The degree to which a system is affected by climate variability or change. The effect may be direct (e.g. a change in crop yield in response to a change in the mean, range or variability of temperature).

Sustainable land management: the adoption of land use systems that, through appropriate management practices, enables land users to maximize the economic and social benefits from the land while maintaining or enhancing the ecological support functions of the land resources (TerrAfrica, 2009).

Vulnerability (to climate change): The degree to which a system is exposed to, and unable to cope with, adverse effects of climate change, including climate extremes and variability .

Vulnerability is a function of the system’s adaptive capacity, sensitivity, and exposure to changing climatic conditions (TerrAfrica, 2009).

2.2. Agriculture and Climate change

Agriculture is impacted by climate change and is also a cause for climate change. Higher temperatures, reduced rainfall and increased rainfall variability reduce crop yield and affects food security in low income and agriculture dependent economies. Thus, the impact of climate change is detrimental to nations that depend on agriculture as the main livelihood, many resides in sub Saharan (tropical) Africa (Houghton et al., 2001). Four ways are identified that climate would have a physical effect on crops (Kurukulasuriya and Rosenthal, 2003). Temperature and precipitation changes directly affect crop production and can even alter the distribution of agro-ecological zones. Secondly, increased level of carbon dioxide is expected to have a positive effect on agricultural production due to better water use efficiency and higher rates of plant photosynthesis. Thirdly, runoff or availability of water is critical in determining the effect of climate change on crop production, especially in Africa. Finally, agricultural losses can result from climate variability and the increased frequency of changes in temperatures and precipitation (including droughts and floods). In middle and higher latitudes, higher temperature will prolong growing seasons and expand crop producing areas towards the pole, thus advantageous to countries in these regions. Whereas, in lower latitudes, it is expected that higher temperature will adversely affect growing conditions, especially in areas where temperature close to or at optimal level for crop growth to begin with (Wachira, 2013). The impacts that climate change will bring about are expected to complicate the vulnerability of livestock systems and to reinforce existing factors that are simultaneously affecting livestock production systems such as rapid population and economic growth, increased demand for food (including livestock) and products increased conflict over scarce resources (i.e. on land, water, bio-fuels etc.). For rural communities losing livestock assets might lead to the collapse into extreme poverty with long-lasting effects on their livelihoods (IFAD, 2007). In some regions, climate change may also cause new transmission models; these impacts will be felt by both developed and developing countries, but developing countries expected to be most impacted because of their lack of resources, knowledge, health and extension services and research technology development (FAO, 2008). Agriculture also caused climate change through the emission of greenhouse gases from different farming practices (Maraseni et al.,2009; Edwards-Jones et al., 2009). Agriculture contributes about 10-12% of total global anthropogenic emissions of greenhouse gases (about 60% of nitrogen dioxide and 50% of methane, as well as significant amounts of carbon dioxide (Maraseni et al.,2009; Edwards-Jones et al., 2009). Emissions also increased by nearly 17% from 1990 to 2005 (Wachira, 2013). As compared to industrial emissions of greenhouse gases, emissions from agriculture are increasing faster in developing countries than in developed ones (Smith et al., 2007). In South Asia emissions are growing mostly because of the expanding use of nitrogen fertilizers (Urea) and manure to fulfill demand for food, resulting from faster population growth (Smith et al., 2007). Burning the stalks after rice or wheat harvesting contributes to climate change in several ways: Firstly, it releases greenhouse gases, notably methane, troposphere ozone, nitrogen dioxide (the carbon dioxide released in this case is consumed by new plants so is not a problem) and aerosols; secondly smokes from fires reduce the reflectiveness or “albedo‟ of the earth’s surface for several weeks causing warming; Finally, fire can kill trees and bushes beside farms that sinks the greenhouse gas carbon dioxide from the air during photosynthesis (Smith et al., 2007).

2.3. Climate Change Views by Smallholder Farmers

In agricultural communities, the linkage between agriculture and climate is much more complex than others, and farmers are able to identify specific and important weather patterns. Farmers usually base their crop and other production decisions using local knowledge systems which are developed from years of observations and experiences. Local knowledge forecasts provide more than just information about the forecast. They provide a set of behavioral rules that households and communities follow when certain indicators are or are not observed. Predicting climate is an important cultural component for farmers (Burton et al., 1993). According to Taddesse (2011) majority of farmers were able to recognize that temperatures have increased and there has been a reduction in the volume of rainfall, still few farmers' lack the perception of change in climatic condition of their area to take steps to adjust their farming activities. Two steps are involved in climate change adaptation; first perceiving change and then deciding whether or not to adopt a particular measure (Maddison, 2007). Whenever they have the opportunity, farmers tend to adopt new variety of measures or technologies in response to the perceived changes of weather conditions. The supports from extension workers, information gained and technologies available to them will highly influence their adaptation and response capacity. For instance, farmers use water conservation techniques whenever the rainfall patterns are changed and amount of rain is reduced. They tend to plant different crop varieties and use short term crops with adjustment of planting dates. These adjustments are done when they perceive reduction in rainfall and changes in the onset and offset of rainy seasons. Human being adapt to climate from the very beginning of their existence through different mechanisms.

IPCC (2007) revealed that adaptation to climate change is already taking place, but on a limited basis. Societies have a long record of adapting to the impacts of weather and climate through a range of practices that include crop diversification, irrigation, water management, disaster risk management, and insurance. Although African farmers have low capacity to adapt to changes in the climate, they have, however, survived and coped in various ways over time. Better understanding of how they have done this is essential for designing incentives to enhance private adaptation. Supporting the coping strategies of local farmers through appropriate public policy and investment and collective actions can help enhance the uptake of adaptation measures that will reduce the negative consequences of predicted changes in future climate, with great benefits to vulnerable rural communities in Africa (Nhemachena and Hassan, 2008). The goal of an adaptation measure should be to increase the capacity of a system to survive external shocks or changes. The assessment of farm-level adoption of adaptation strategies is important to provide information that can be used to formulate policies that enhance adaptation as a tool for managing a variety of risks associated with climate change in agriculture (Nhemachena and Hassan, 2007). Adaptation strategies are also necessary to overcome the expected adverse impacts from higher temperature and changing precipitation patterns (Kurukulasuriya and Mendelsohn, 2007). Therefore, a key component of climate adaptation involves building resilience, where resilience is the capacity of a system to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes: a resilient system can withstand shocks and rebuild itself when necessary (FAO, 2003). For poor farmers, adaptation strategies to climate change are vital because failure to take adaptation measures could lead to social problems and displacement (Downing et al., 1997). To approach the issues of climate change appropriately, the local communities' or farmers understanding and level of awareness about climate change is determinant factor. Farmers perceive climate change as having a strong spiritual, emotional, and physical dimension (Apata et al., 2009). Benedicta et al. (2010) have shown that farmers are well aware of climate change, but few seem to actively take steps toward adjusting their farming activities. The main adaptation strategies of farmers identified include change in crop types, planting short season varieties, changing planting dates, and crop diversification. The results of determinants of adaptation strategies suggest that land tenure, soil fertility, and access to extension service and credit are the most significant factors affecting the adaptation capacity of farmers.

2.4. Smallholder Farmers Adaptation Strategies to Climate Change

Adaptation to climate change and risks takes place in a dynamic social, economic, technological, biophysical, and political context that varies over time, location, and sector. This complex mix of conditions determines the capacity of systems to adapt. Adaptive capacity varies considerably among regions, countries, and socioeconomic groups. The ability to adapt and cope with climate change impacts is a function of wealth, technology, information, skills, infrastructure, institutions and equity. Groups and regions with limited adaptive capacity are more vulnerable to climate change damages (Burton et al., 1993). Openness to the development and utilization of new technologies for sustainable extraction, use, and development of natural resources is a key to strengthening adaptive capacity (Goklany, 1995). For example, in the context of Asian agriculture and the impact of future climate change, Iglesias et al. (1996) note that the development of heat-resistant rice cultivars will be especially crucial. Regions with the ability to develop technology have enhanced adaptive capacity. Lack of trained and skilled personnel can limit a nation's ability to implement adaptation options (Scheraga and Grambsch, 1998). In general, countries with higher levels of stores of human knowledge are considered to have greater adaptive capacity than developing nations and those in transition (Smith and Lenhart, 1996). Magalhães (1996) includes illiteracy along with poverty as a key determinant of low adaptive capacity in northeast Brazil. The role of inadequate institutional support is frequently cited in the literature as a hindrance to adaptation. Kelly and Adger (1999) showed how institutional constraints limit entitlements and access to resources for communities in coastal Vietnam and thereby increase vulnerability. Magadza (2000) showed how adaptation options in southern Africa are precluded by political and institutional inefficiencies and resulting resource inequities.

2.5. Empirical Studies on Determinants of Adaptation Strategy to Climate Change

A lot factors affect the decision of the household to choose among adaptation strategy employed to climate change in agriculture. Different studies are conducted on the determinants of climate change adaptation strategies in many part of the world including Ethiopia, using multinomial logit model. Taddesse (2011) indicated that male headed household, those educated and those with large family size tend to adapt crop diversification adaptation method to cope with adverse impacts from climate change. Likewise, households with larger land size, livestock and higher farm income have higher probability of preferring soil and water conservation as an adaptation method. Access to credit, extension services and climate change information among the households are positively associated with preferring adjusting planting date adaptation method. Dhaka et al. (2010) revealed that the farmer's best placed to pronounce on whether climate change has occurred are presumably those who have had the most experience of farming and who are innovative, environmental conscious and having exposure to mass media. Furthermore, it shows that more experienced farmers are more likely to take up an adaptation strategy. Being recipient of extension advice relating to either livestock or crop production also strongly increases the probability of the farmers' adaptation. The respondent's level of education also greatly increases the probability of adaptation (Temesgen, 2010). Households who have access to extension services on crop and livestock tend to go for sold livestock and borrowed from relatives (Temesgen, 2010). Whereas farm income is negatively related to sold livestock and eats less strategy. It also showed that livestock ownership significantly increases selling livestock only; and borrowing from relatives and selling livestock combined as coping strategies to climate change. According to Aymone (2009) the farming experience shows that experienced farmers tend to increase likelihood by using portfolio diversification, changing planting dates, and changing the amount of land under production. Household size is positively related with "other-Soil conservation, tree shading, migration and shifting to livestock" category (Temesgen, 2010). Wealthier families opt for changing plant dates, and surprisingly in the study the results suggested that education level and gender did not have a significant impact on the probability of choosing any adaptation technique (Aymone, 2009). Nhemachena and Hassan (2008) results suggest that a warmer winter-spring positively related with use of irrigation, multiple cropping and mixing crop and livestock activities especially under irrigation. While it is clear that irrigation is the strongest adaptation measure against warming for all systems, mixing livestock with crop cultivation seems to work only with multiple cropping under dry land conditions. Better access to extension and credit services, educated and as well more experienced farmers seems to have a strong positive influence on the probability of adopting all adaptation measures and abandoning the relatively risky mono cropping systems (Aymone, 2009). Temesgen et al. (2005) had studied determinants of adaptation to climate change in Ethiopia and South Africa. Study from determinants of adaptation from Ethiopia, reveals that educated farmer tends to go for soil conservation and changing planting dates; age is positively related with planting trees and irrigation; access to extension is positively related with planting trees, access to credit is positively related with soil conservation, changing planting dates and irrigation and access to climate information is switched to changing crop varieties. Household size is also negatively related with changing planting dates (Temesgen et al., 2005).

2.6 Climate Change and Land Management

The dynamic nature of climate change should be taken into account in order to ensure that land management practices indeed meet the intended goals. LMP has the potential to mitigate climate change and strengthen the resilience to its impacts, while advancing broader development objectives, such as poverty alleviation and economic growth, food security and environmental health. The impacts of climate change on future land use, agriculture and food security are predicted to be negative throughout much of Africa, as a result of rising temperatures everywhere, and declining and more variable rainfall in many locations. These impacts will exacerbate and be exacerbated by widespread land degradation in SSA (Gautam, 2006).

The importance of land-cover change in altering regional climate in Africa has long been suggested. Gautum (2006) indicated that vegetation patterns help shape the climatic zones of Africa and, changes in vegetation result in alteration of surface properties and the efficiency of ecosystem exchange of water, energy and CO_2 with the atmosphere. Climate change and variability can contribute to land degradation by making current land management practices unsustainable through inducing more rapid conversion of land into unsustainable practices.

Climate change may offer new opportunities for sustainable land management by enhancing rainfall or growing periods in some places or through creating markets that might pay farmers for improved sustainable land management practices (Gautam, 2006). Sustainable land management can also reduce vulnerability to climate change and increase people's ability to adapt and in many cases can contribute to climate change mitigation through improved carbon sequestration and reduced greenhouse gas emissions (Cline, 2007; Pender, 2008).

In Ethiopia, farmers, especially those living in marginal environments and in areas with low agricultural productivity, depend directly on genetic, species and ecosystem diversity to support their way of life. As a result of this dependency, any impact that climate change has on natural systems will threaten their livelihoods, food intake and health. There are situations, which make Ethiopia particularly vulnerable to climate change: water resources, especially in international shared basins where; there is a potential for conflict and a need for regional co-ordination in water management; food security, at risk from declines in agricultural production; natural resources productivity and biodiversity at risk; vector- and water-borne diseases, especially in areas with inadequate health infrastructure; river bank areas vulnerable to flood hazard, particularly roads, bridges, buildings, and other infrastructure that is exposed to flooding; and lastly exacerbation of desertification by changes in rainfall and intensified land use (SRA, 2006).

3. METHODS

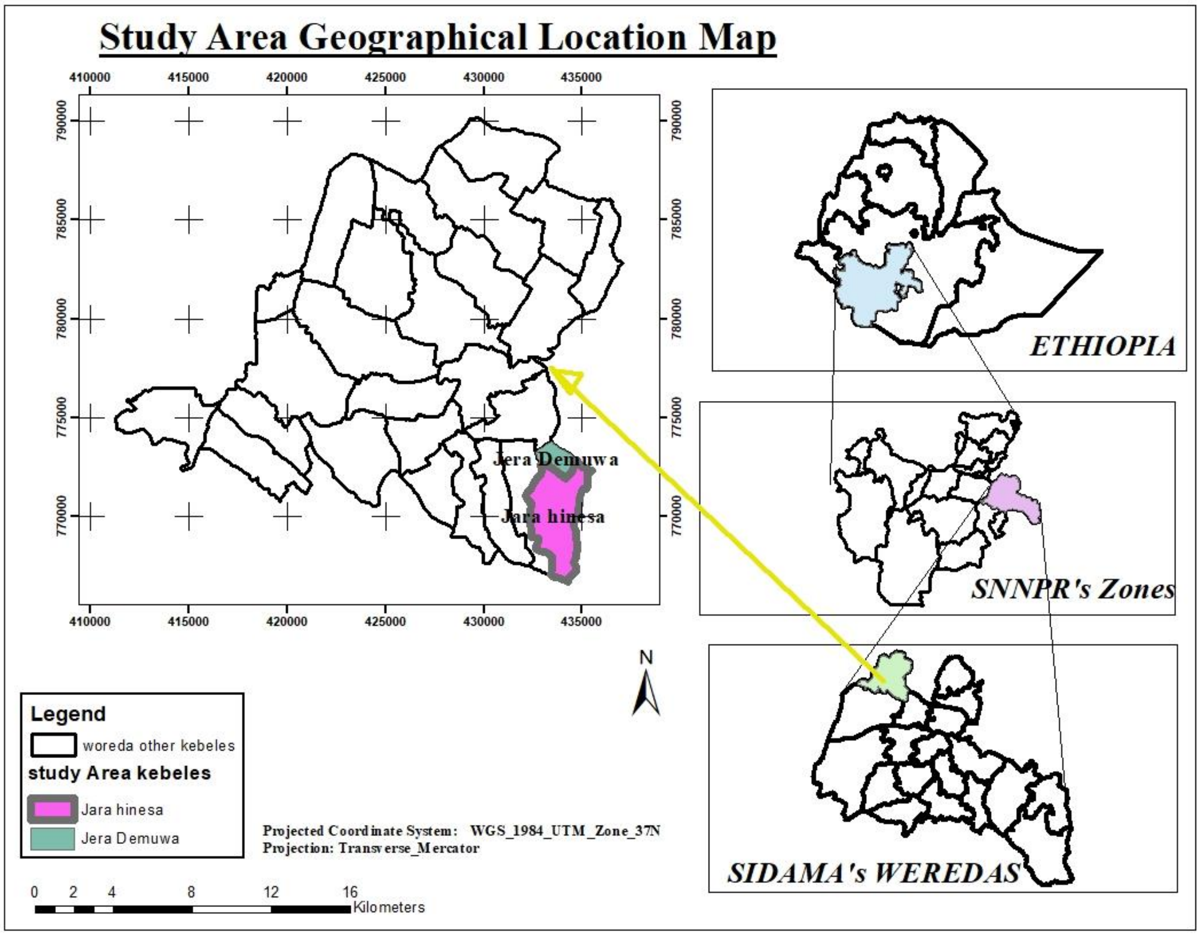
3.1 Description of the Study Area

The study were carried out in Hawassa zuriya district, and it is located 297 kms and 23kms away south from Addis Ababa and Hawassa (the capital town of Sidama zone and SNNPRS) respectively. And its geographical location of the study area lies between coordinate 6^0.49" to 7^0 .15" North latitude and 38^0.19" to 38^0 .43" East longitude (BOFED, 2015). The district lies between 1501-2500 m above sea level As a result of these altitudinal variations, the district is found in W/Dega (Midland), and Dega (Highland) traditional agro ecological zones and it covers an area of 305 km2 (IBID). The district constitutes 24 kebelles (23 rural and 1 urban kebelles) of whch six can be termed as midland and eighteen are dry or semi-dry lowlands (Seyoum 2015). The estimated population is 155,245 of which 78293 are males and 76951 are female (BOFED,2015). It has a Population density of 509 persons per square kilometer (BOFED,2015) .

3.1.1 Land Use

According to the information from Hawassa Zuriya woreda agriculture and natural resources office, there are five traditional land use types in the district. Farmland occupies the largest portion of all land use types (about 89.5%) and gazing and forestland (including bushes) about 40 ha and 33 ha of the total area respectively. Of the total farmland, perennial and annual crops account for 8060.83 and 4765.17 ha respectively. Multiple cropping is the dominant form of farm practices. Even though the watershed has the long boundary with Lake Hawasa, there are no water bodies and wetlands in the watershed. According to the information of Woreda agriculture, about 40% of the grazing land is privately owned and the rest 60% communal. Homestead/settlement account for about 270 Ha mainly occupied with enset, trees, and household infrastructure such as housing and animal shelter. Gullies account for 67 ha and hill side/ degraded areas about 1024 ha.

Figure 1 study area (Source developed from CSA GIS data: own development).



3.1.2 Livelihood conditions

Major livelihoods of the population of the district are traditional and intensive farming of crops and animal husbandry, none and off farm activities and petty trade (MANR 2016). Average land holding is about 0.73 ha (ranging from .04-3ha) and all registered households are land owners. The livelihood of the majority of the households in the district depended on production of maize, sorghum, pulses (haricot beans), and teff, wheat, pulses, enset, fruits and vegetables. Maize, pulses and enset however are the three major crops occupying a total area of about 9530.34 hectares with productivity of 65, 20 and 12 quintals per ha respectively (MANR, 2016). Average productivity of other crops includes sorghum 1500 kg vegetables 5000 kg and teff 800 kg. Almost 82% of households produce these crops (including 5000 male and 225 female-headed households) (MANR 2016). On the other hand, about 5% of the households depend on none/off farm activities in addition to crop farming and livestock rearing (MANR 2016). According to the information, about 4% male and 5% female-headed households have at least one participant in these activities. Another 40% of households also engage in casual/wage labor. The average annual gross income of the household is estimated at about 15833 Birr. Over 80% of this income is from crop production, 4% from livestock 12% from non-farm activities and 4% from natural resources extraction (HZWOA).

3.1.3 Climate and Soil type

95% of the Wereda is with Woynadega climatic zone, 5% Dega (moderate) (HZWOA). The woreda receives an average rainfall of 900 mm, ranging from 801mm to 1000 mm with average temperature ranges from 17.6-22.5^{o}C (BOFED, 2015). Dominant soil types are fluvisols and vertisols while andosols and nitisols are inclusion (HZWOA,2015). The rationale for selecting the study area is that the area is characterized by overexploited soils, deforestation and overgrazed land resulted from high human and animal population it has supported for decades, low agricultural productivity, severe land degradation, and other environmental problems including climate change (HZWOA, 2015) .

3.2 RESEARCH METHO

3.2.1 Study design

This research used both quantitative and qualitative research methods. The research were conducted through a cross-sectional survey design and concerned with examining, understanding, describing and exploring the benefits of land management practices to enhance adaptive capacity in Hawassa zuriya woreda. The design enabled the researcher to consider issues such as economy of the design, rapid data collection and ability to understand population distributions and resource use. For the purpose of this study use of cross-sectional survey design were adapted with a view of improving the benefits of land management practices in two purposively selected Kebeles (Jara hinessa and Jara Damuwa) which touch all the three topographic classification of the watershed.

3.2.2 Sampling techniques

The study employed two main sampling strategies; probability and non- probability sampling techniques. In probability sampling techniques, stratified and simple random were used, and for non-probability sampling techniques convenience and purposive sampling were applied. In this study a multi-staged sampling technique was employed. In the first stage, the study district, Hawassa, was selected purposively considering its long term experiences to climate change and variability induced land management practices as adaptive strategy and related research gap in the area. Secondly, two rural *kebele*s from 24 were selected purposively in consultation with experts of the district and previous knowledge on the area as well as based on their vicinity to the meteorological station. Finally, household heads for household survey were selected using random sampling technique considering probability proportional to size (PPS) of each of the two selected rural kebeles). Household list of each selected kebeles were collected from each kebeles rural land administration offices and then households were sampled using simple random sampling technique. Then household survey was administered and data were collected and analyzed.

Sample size

The target population consisted of 155,245 people and the average family size is 5.3 and total house hold is 29184 . The sample size consised of 123 households. There are a number of approaches for determining the sample size in research. For this study simplified formula provided by Yamane, (1967) was adopted to determine the required sample size at 95% confidence level with degree of variability = 0.5 and level of precision (e) = 9%.

$$n= N/1+N(e)^2$$

Where n is the sample size, N is the population size (total household size), and e-is the level of precision. Based on this formula the total sample size required is 123 sample households but to make use of the opportunity of larger sample size this study used 126 sample households

3.2.3 Data collection

This study relied on both primary and secondary sources of data. Key informant interviews, and focus group discussions were conducted to augment information generated through semi structured interview schedules.

3.2.3.1 Secondary Data Sources

Secondary data were synthesized from books, periodicals, journals, newsletters, electronic media (internet) and reports from the government ministries and the District Reports. Land management related publications and articles were also be reviewed with a view of gathering information on climate change and variability, land management practices and their roles on climate change adaptation. Daily rainfall data recorded at Hawassa meteorological station were Collected for the period of 1987-2016 (30 years) to detect trend and variability of rainfall in the area. According to WMO 1989 in climatic time series 30 years data are recommended as a minimum data to get evidence of climate change. The major sources for this information were relevant government offices' and Non-Governmental Organizations' reports and records, research papers related to rainfall trend, its impacts on crop production, and common adaptation strategies exercised in the study area.

A) For objective 1(climatic data)

Climatic data were collected from Hawassa Meteorological station, interviews, focus group discussions and secondary data were collected from journals, books, reports, periodicals and web based sources.

3.2.3.2 Primary Data Sources

B) For Objective 2 (LMP inventory)

Primary data sources were gathered using semi structured interviews, observations, key informant interviews and focus group discussions. The following table shows the inventory procedure.

Table 1 Land management inventory criteria's

S/N	Type of LMP	Year of establishment	Current status	Supported by(Government,NGO...)	Intended purpose	Benefits obtained	Disadvantage

Semi-Structured Interview Schedules

Semi-structured interview schedules were administered to 126 respondents. 13 households in the upper part of the watershed with in the selected kebelle , 60 households from middle part and , 52 households from the lower part of the watershed with in the selecte kebelles. The semi structured interview schedules generated both qualitative and quantitative data that were collected through self-administration by the researcher.

Key Informant Interviews

The key informants interviewed were 13 in number, this represented 10% the of sample size (N=126). The key informants were selected purposely with an intention to elicit an incisive and enlightening opinion of land management practice to enhance adaptive capacities of farmers. They included; 1 development team leader, 1 DA, 1 upstream households, 2middle households, 1from lower part of the waershed,1the chairman of the kebelle, 2 the project community facilitatort, 1 project focal person, 1 BOA official, , and 2woreda expert. The key informants were engaged in personal interviews using an open-ended interview guide to obtain information on land management practice and their benefits to climate change adaptation,climate change trends as well as their effects on agriculture and income .

Focus Group Discussions

For proper facilitation of the discourse, focus group discussions were organized. The focus group were comprise of 5-8 members to be manageable. An open-ended question guide were used to generate information within the groups. Four focused groups were conducted (each group was given 4 hour for discussion) the area of discussion were on giving rank to the identified LMP, benefits of those LMP, comparison of users and non users of those LMP and on climate trends.

C) For Objective 3

The same procedure as objective 2 were employed and the selection of those land management practices for this research activity were as per the following criterion(table,2) and pair wise ranking.

Table.2 Selection criteria for land management practices among others

s.no	Biophysical(High ,medium ,low)	Socioeconomic(High ,medium,low)	Rank
	Increased water quantity and quality	Increased recreational opportunities	
	Reduced surface runoff	Strengthening of community institutions	
	Improved excess water drainage	Improved conservation/erosion knowledge Conflict	
	Recharge of groundwater table	Improved situation of socially and economically disadvantaged groups (gender, age, status,	

		ethnicity)	
	Reduced climate risks (floods, droughts, storms) h	Improved food security and self-sufficiency (reduced dependence on external support)	
	Reduced wind velocity	Improved health	
	Improved soil cover	Improved level of income	

3.3 Meteorological data quality diagnosis (Obj,1)

Estimation of missing data*:* The raw dataset obtained from NMSA had no any missing data within the study period of 1987-2016 monthly records of rainfall and temperature data.

Outlier detection: Outliers are observations whose values are quite different than others in the dataset or values greater than a threshold value of a specific time series data that can affect the detection of in homogeneity (Mulat, 2016). This study employed graphical method to identify outliers and then suspected outlier data were checked to verify that neighboring stations had such high rainfall. In such a process no major anomaly was found in the dataset of this study. Other studies also applied this method to address the issue of outliers in their dataset (Seleshi and Camberlin, 2006 as cited in Mulat, 2016).

Homogeneity Test*:* Long-term climate analyses should be based on homogeneous data - where variations are caused only by variations in weather and climate - to get accurate and unbiased results (Peterson *et al*., 1998). However, most long-term climatic series are affected by non-climatic factors: changes in instruments, station location, or environment. A comprehensive review of direct and indirect homogeneity test is given by Peterson *et al.* (1998). This study used a double-mass curve method which was commonly used in the climatology to detect in homogeneities (Ayalew *et al*., 2012). It is a graphical procedure where the rainfall values of the station are accumulated on the Y-axis and the cumulative total of other stations (assumed to be homogeneous) on the X-axis. Falling of plotted points along a straight line indicates data homogeneity (Das, 2009). If a change in slope occurs, it is considered significant only if it persists for more than 5 years. This study followed the approach and found that all the data recordings are homogenous.

Test of randomness: One of the problems in detecting and interpreting trends in hydrologic data is the confounding effect of serial dependence (Partal and Kahya, 2006). It is suggested that time series data required for trend analysis should be 'pre-whitened' before applying trend analysis to eliminate the effect of serial correlation (Karpouzos *et al*., 2010 as cited in Mulat, 2016).

In this study the time series data were tested for randomness and independence using the autocorrelation function ($r1$) as described in Box *et al.* (2015) in the following manner.

$r1=\Sigma(X_i-X)(X_{i+1}-X)n-1\ i=1\Sigma(X_{i-X})2ni=1$-- Equation (3)

Where X_i is an observation, X_{i+1} is the following observation, X is the mean of the time series, and n is the number of data. In addition, Dahmen and Hall (1989) as cited in Hadgu *et al.* (2013) defined the critical region at 5% probability as follows;

$[(-1\pm1.96\sqrt{n}-2)(n-1)]$ -- Equation (4)

Serial correlation of lag-1 was employed in this study. When the calculated lag-1 serial correlation coefficient (r_1) was at the 5% level, the data series has been 'pre-whitened' following the procedure described in Partal and Kahya (2006). The pre-whitened data series may be obtained as: $X_2 - r_1 X_1$, $X_3 - r_1 X_2, \ldots, _{n-r1} X_{n-1}$------------------------- Equation (5)

However, as all lag-1 serial correlation coefficients in this study were statistically not significant, there was no need to pre-white the data, and all statistical tests described below were applied to the original time series data

3.4 Data Analysis

Quantitative and qualitative techniques were used for data analysis. Data analysis was begin by ensuring that the interview schedules were correctly filled in. Summary tables were then prepared on all the responses. Qualitative data analysis were done through triangulation of narratives from focus group discussion, key informant interview and evidence from field observations. The summaries of the narrations were used in the discussion in subsequent sections. Quantitative data were, processed and analyzed using Statistical Package for Social Science (SPSS) 20^{th} version and the meteorological data were analyzed using XLSTAT, and Microsoft excel. Frequency distribution and cross tabulation were also used to compare different variables .

3.4.1 Meteorological data Analysis

A number of techniques have been developed for the analysis of rainfall and temperature, which generally categorized in to two namely, variability and trend analysis. Variability analysis involves the use of Coefficient of Variation (CV), percentage departure from the mean (Anomalies), and Precipitation Concentration Index (PCI) .

Trend Analysis

Trend detection and analysis are performed through parametric and non-parametric tests only for consistent data. Homogeneity and Normality of variance throughout the series may be seriously affected by outliers and missing data in parametric tests. The advantage of non-parametric statistical test over the parametric test is that the former is more suitable for non normally distributed, outlier, censored and missing data, which are frequently encountered in hydrological time series (Hadgu *et al*., 2013; Muluneh *et al*., 2016). As a result, Mann-Kendall (MK) test is widely used to detect trends of meteorological variables (Tabari et al., 2015).

Mann- Kendall (MK) test

MK test is a non-parametric test, which tests for a trend in a time series without conidering the linearity of the trend (Yue et al., 2002). In this study, temperature and precipitation variability were computed using CV, Standardized Precipitation Anomaly and precipitation concentration index (PCI). Moreover ,Man Kendal test with Sen's slope estimator was used to detect the precipitation and temperature trends in the study area.

Based on MK test, the null hypothesis $H0$ assumes that there is no trend and this is tested against the alternative hypothesis $H1$, which assumes that there is a trend.

$H0$: There is no monotonic trend in rainfall dataset of Hawassa station for the selected rainfall indices over the period 1987 – 2016.

$H1$: There is a monotonic trend (increasing or decreasing) in rainfall dataset of Hawassaa station for the selected rainfall indices over the period 1987 – 2016.

Computational procedure for the MK test takes the time series of n data points and $\mathbf{X_i}$ and $\mathbf{X_j}$ as two subsets of data where $i = 1,2,3,\ldots,n-1$ and $j = i+1,i+2,i+3,\ldots,n$. The data values are evaluated as an ordered time series. Each data value is compared with all consecutive data values. If a data value from a later time period is higher than a data value from an previous time period, the statistic S is incremented by 1. Whereas, if the data value from a later time period is lower than the preceeding, S is decremented by-1. The net result of all such increments and decrements yields the final value of S. The Mann-Kendall S Statistic is computed as follows:

S= $\sum_{i=0}^{n-1} \sum_{j=i+1}^{n} \boldsymbol{Sgn}(\mathbf{Xj} - \mathbf{Xi})$---Eq1

Sgn (X_i-X_j) = $\begin{cases} +\mathbf{1}\boldsymbol{If}(\mathbf{Xj} - \mathbf{Xi}) > \mathbf{0} \\ \mathbf{0}\ \boldsymbol{If}\ (\mathbf{Xj} - \mathbf{Xi}) = \mathbf{0} \\ -\mathbf{1}\ \boldsymbol{If}(\mathbf{Xj} - \mathbf{Xi}) < \mathbf{0} \end{cases}$ ----------------------------------Eq2

Where Xi and Xj are the annual rainfall values in years j and i, j>i respectively. For $n \geq 10$, the statistic S is approximately normally distributed with the mean and variance as follows:

(S)=0

The variance ($\sigma 2$) for the S-statistic is defined by:

For $n \geq 10$, the statistic S is approximately normally distributed with the mean and variance as follows: (S)=0

The variance ($\sigma 2$ (var(s))) for the S-statistic is defined by:

$Var(S) = 1/18\left[n(n-1)(2n+5) - \sum_{i=1}^{m} \mathrm{ti}(\mathrm{ti}-1)(2\mathrm{ti}+5)\right]$----------------------------Eq3

Where $'m'$ is the number of tied groups in the dataset and ti is the number of data points in the ith tied group. The summation term in the numerator is used only if the data series contains tied values.

The standard test statistic ZMK was calculated as follows

$$\mathbf{Z_{MK}} = \begin{cases} \frac{S-1}{\sqrt{Var(S)}} \; If S > 0) \\ 0 \; if \quad S = 0 \\ \frac{S+1}{\sqrt{Var(S)}} \; If \; S < 0 \end{cases} \text{---Eq4}$$

Then the calculated values of the test statistics (**Z_{MK}=**) were compared with the critical value ($Z\alpha/2$) to make decision. The statistic Z has a normal distribution.

If |ZMk| ≥ $Z\alpha/2$, then the Ho will be rejected meaning that the trend is significant.

If |ZMk|< $Z\alpha/2$, then Ho will be accepted indicating that there is no significant monotonic trend in the dataset.

Where α indicates the chosen significance level (in this study 5% (α0.025= 1.96) and 10% (α0.05= 1.65) probability level was applied to determine statistical significance of trend).

Variability analysis

CV is calculated to evaluate the variability of the rainfall. A higher value of CV is the indicator of larger variability, and vice versa which is computed as:

$$\mathbf{CV} = \frac{\sigma}{\mu} \times 100 \text{--Eq5}$$

where CV is the coefficient of variation; σ is standard deviation and μ is the mean precipitation. According to Mulat (2016), CV is used to classify the degree of variability of rainfall events as less (CV< 20), moderate (20 < CV <30), and high (CV >30). PCI is used to examine the variability (heterogeneity pattern) of rainfall at different level (seasonal or annual). According to De Luis et al. (2011) the PCI values were computed as:

$$PCIannual = [\left[\sum_{i=1}^{12} \mathrm{Pi}^2 / (\sum_{i=1}^{12} \mathrm{Pi})^2 \times 100\right] \text{---Eq6}$$

$$\text{PCI seasonal} = \left[\sum_{i=1}^{12} \mathrm{Pi}^2 / (\sum_{i=1}^{n} \mathrm{Pi})^2\right] \times \frac{n}{12} \times 100 \text{-----------------------------Eq7}$$

where: Pi the rainfall amount of the ith month, n is number of months considered in the season. i.e. is 3, 4, and 5 for **Belg, Kiremt**, March-September, and **Bega** season, respectively (Seyoum 2015). PCI values of less than 10 indicates uniform monthly distribution of rainfall (low PCI), values between 11 and 15 indicates moderate concentration, values from 16 to 20 denotes high concentration, and values ≥ 21 indicate very high concentration. On top of this, Standardized Rainfall Anomalies (SRA) have been calculated to evaluate the nature of the trends, enables the determination of the dry and wet years in the record and used to assess frequency and severity of droughts (L. Muthuwatta, et al., 2017) as:

$$Z = (\mathbf{Xi} - \overline{X}\, i)/s \text{---Eq8.}$$

where, Z is standardized rainfall anomaly(SRA); Xi is the annual rainfall of a given year; $\overline{X}\, i$ is long term mean annual rainfall over a period of observation and 's' is the standard deviation of annual rainfall over the period of observation. According to Agnew and Chappel (1999), the drought severity classes are extreme drought (Z < _1.65), severe drought (_1.28 > Z > _1.65), moderate drought (_0.84 > Z > _1.28 and no drought (Z > _0.84).

Sen's estimator of slope

To calculate the true slope of an existing trend (rate of change over time) the Sen's non-parametric method (Sen, 1968) was employed. This estimator is not sensitive to outliers in the series and has been widely applied in hydro-meteorological series, e.g., (Muluneh *et al*., 2016).

The Sen's method can be used in cases where the trend can be assumed to be linear (Mulat 2016).

$$(t)=Qt+B\text{- -- Eq(9)}$$

Where Q is the slope and B is a constant. The Sen Slope estimator is the median of all pair-wise slopes in the dataset. In other word to get the slope estimate Q we first calculate the slopes of all data value pairs.

$Q_t = \frac{Xj - Xi}{j-i}$ -- Eq10

Where j > i If there are n values Xj in the time series we get as many as $N = \frac{n(n-1)}{2}$ slope estimates Qt. where xj and xi are considered as data values at time j and i (j > i) correspondingly. The median of these N values of Ti is represented as

Sen's estimator of slope which is computed as

$$\text{Qmed} = \begin{cases} T_{[N+1/2]} & If\ N\ is\ Odd \\ \frac{1}{2}\left[\ T_{\left[\frac{N}{2}\right]} + T_{[N+2/2]}\ \right] & If\ N\ is\ Even \end{cases}$$ ---Eq11

A positive value of Qi indicates an upward or increasing trend and a negative value of Qi gives a downward or decreasing trend in the time series.

To obtain an estimate of *B* in equation *(9)* the n values of differences $xi - Qt$ are calculated. The median of these values gives an estimate of *B* (Sirois, 1998).

$Bi = Xi - Qti$

Where *Q* is the slope obtained using equation *13* and $ti = Year - First\ year$**.**

$$B = \begin{cases} B_{[n+1/2]} & If\ n\ is\ Odd \\ \frac{1}{2}\left[\ B_{\left[\frac{n}{2}\right]} + B_{[n+2/2]}\ \right] & If\ n\ is\ Even \end{cases}$$ ---Eq12

4. RESULTS AND DISCUSSION

4.1 General Characteristics Of Respondents

The findings revealed that 65.95% of the respondents are within the healthy age group of 15-65 years, fit for land management activities (Table 3). They are followed by dependent respondents of age < 15 years and > 65 years old 15.1% and 19%respectively . The implication of this to the study is that these individuals have put it an average of age of 38 in farming activities and practice land management for climate change adaptation. The result shows that all the surveyed house hold heads are married. Greater number (59.5%) Hold ≤ .5 hectares of land and are followed by 24.36% who hold between 0.56 – 1 hectares of land. Only about 3.2% , 4.8% and 7.9 cultivate 1-1.5 hectares ,1.5-2 hectare and above 2 hectares respectively. The size of the farm has implications on vulnerability and adaptation to climate change, with smaller land holding, farmers will have lesser chance to carry out alternative activities on land. Potentially, those who hold relatively larger land size could afford to do lesser cultivation and put the land to alternative uses (Seyoum,2015). Studies by Ghirotti, 1998 indicates that fragmented, small size or scale of activity is the main characteristics of smallholders. Obviously, population growth in both the rural and urban areas reduced the land available for farmers. Examples also abound where expansion of Hawassa town into the adjacent rural communities reduced the land available for local farmers. Majority of the respondents are illiterate as indicated by 40.5%, then, 29.4% can read and write with only 21.4% and 8.7% receiving primary and secondary education respectively. This indicates that the household heads interviewed had low educational status. Educational status of HH head determine positively on access to information and subsequently to the adoption of adaptation technologies (Deressa *et al*., 2009). Thus, the low educational status of the majority of HHs had likely been limited them from access to and adoption of improved adaptation technologies and practices. The level of education deters in practicing of recommended Land management practices. The respondents have large families of 3-6 members (53.2%), 7-9 members (25.4%), 10 members and above 11.1% and 1-3 members for 10.3%. The average family size of the study area 6.07. The result in Tabe,3 also indicated that the family size of the respondents varied from 2 to 14 with an average household size of 6.07 persons per HH, which is above the national average rural family size of 4.9 persons per HH (CSA, 2007).This indicates high fertility rate and the importance of extended family system. The use of family labour for economic activities is an attraction to have more family members. Moreover, in a rural society where pension and insurance system is absent, parents prefer to have more children to support them in old age(Seyoum, 2015). However, larger family size also carries the seeds of increased vulnerability when combined with shortage of land, climate change and food insecurity. Other research by Mulat,2016 also indicates that family size is associated with the availability of labor force that may enable the HH to accomplish labor intensive adaptation strategies. This is true in the study area as shown in Fig,2 96% of the labor source is from family 11.9% from shared labor and 50% of them use animal traction in combination, no one of them uses machinery (Tractor) for farming. On the other hand larger family size also creates pressure on land to support beyond its carrying capacity. On top of this it also aggravates the land degradation problem through encroachment of fragile and marginal lands for agriculture as it is the case around the lake. people are plowing the lake shore that otherwise to be the buffer zone. The good news here is that 100% of the respondents are visited by extension agents and get the technical support they require at any time . Farming is the major occupation of majority (98.6% crop production and livestock rearing) where as the remaining get income from other sources. Out of the total farm households interviewed (Fig 3 and table 3) only 27.6 % had earn income from Off-farm sources like petty trading(32.5%), daily the nearby towns (Hawassa) and markets labor(15.1%), remittance(5.6%), salary(1.6) this can also be associated with level of education lower level of education forced them not to get better job. The result also showed that majority of the HH heads were male (90.5%). The survey result indicated that majority of the respondents had access to climate information (98.7%) and credit services (88.1%). However, with regards to access to extension service, 100% had reported having the access.

Table 3 Socio economic characteristics of respondents

Description	**Frequency**	**Percentage**
Gender		
Male	114	90.5
Female	12	9.5
Education		
Illiterate	51	40.5
Read and wright	37	29.4
Primary educ	27	21.4
Secondary educ	11	8.7
Livelihood		
Crop production	11	8.7
Crop and livestock	112	88.9
Other	3	2.4

House hold size		
1-3	13	10.3
4-6	67	53.2
7-9	32	25.4
>10	14	11.1
Land holding (Ha)		
≤ .25	28	22.2
.25-.5	47	37.3
.5-1	31	24.6
1-1.5	4	3.2
1.5-2	6	4.8
>2	10	7.9

Source own survey 2018

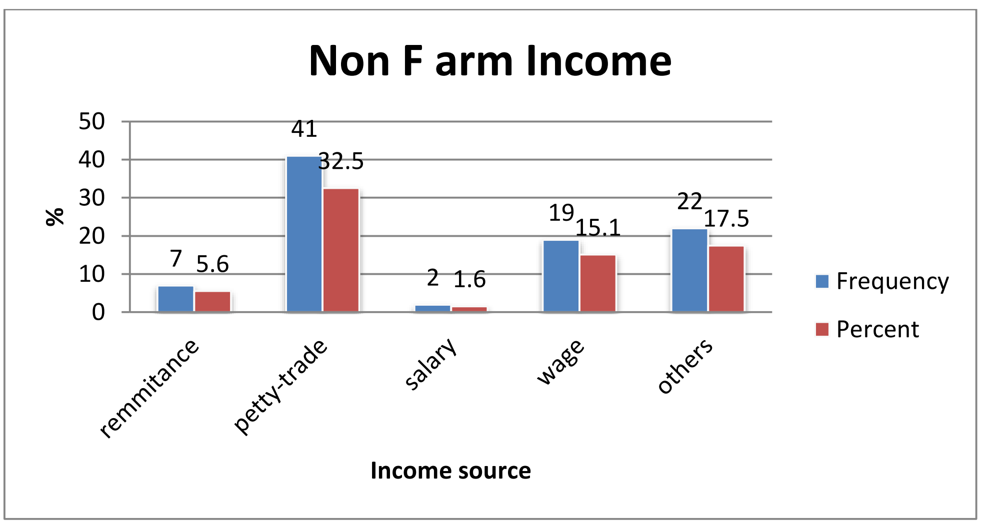


Fig2 Income sources of respondents :source own survey 2018

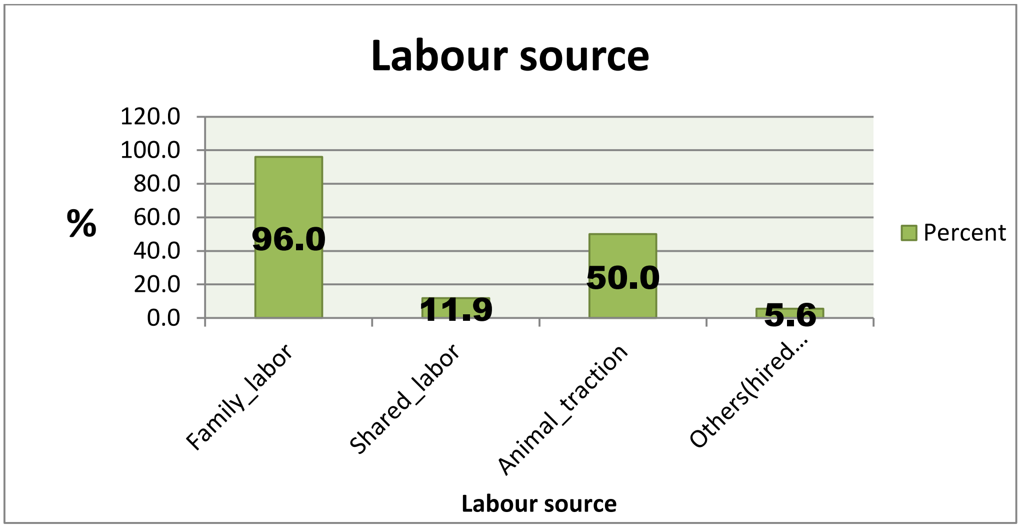


Fig3 Labour sources of respondents :source own survey 2018

4.2 Rain fall variability and trend Results

4.2.1 Variability analysis (rainfall)

The mean annual rainfall of Hawassa zuria district during the study period was 953.5.mm with 139.5 mm standard deviation and 15. % CV. The minimum and maximum ever recorded rainfalls were 670.9 mm in 2015- the driest year and 1197.9 mm (in 2006-the wettest year) per year respectively. The result of normality test (using double mass curve) for all the distribution type(anual, bega and kiremt) indicated that the rainfall data of the area at significance level of 5%; were not found to be normally distributed. As depicted in **Table 4,** Belg and Kiremt is the major rain season in the study area which contributes about 32.1% and 48.12% of the total rain respectively.

Table *4*: Descriptive statistics of rainfall at Hawassa station for the period 1987 to 2016

Descriptive statistics	Annual Rainfall	Total seasonal Rainfall	
		Belg (MAM)	Kiremt (JJAS)
Mean (mm)	953.5	306.0(32.1%)	458.9(48.12%)
Standard Deviation (mm)	139.5	87.1	106.8
Co-efficient of Variation (%)	15%	28%	23%
Maximum (mm)	1197.9	510.0	692.6
Minimum (mm)	670.9	123.2	280.0
Mean PCI (%)	12.39%	11.69%	9.07%

Source: Calculated from meteorological data obtained from NMA of Ethiopia

As shown in **table 4**, though the increasing trend of belg rainfall is not statistically significant, the CV (28) is higher than that of kiremt rainfall (23) which implies more inter annual variability of belg rainfall than kiremt one, though in both cases the changes are moderately variable(CV between 20-30). The result agrees with the findings of Seyoum (2015), Cheung et al. (2008) and Arragaw and Woldeamlak (2017) where more variability in belg rainfall than the kiremt rainfall in most parts of Ethiopia was observed. Using a linear regression model (see Fig. 9), the rate of change is defined by the slope of regression line which in this case is about -0.318 mm/year, +2.0116 mm/year and +.2805 mm/year for annual, kiremt and belg, rainfall respectively. The declining trend for annual rain fall was smaller, this may be because of the increasing trend of Belg and Kiremt rainfall even if they were found to be statistically non significant (Table 5). The result revealed that rainfall has been decreased in the study period (1987-2016). The rainfall anomaly also witnessed for the presence of inter annual variability and the trend being below the long-term average becomes more pronounced particularly since the 2007 (Fig. 6). Very low values of rainfall anomaly correspond to severe drought periods and the value in the study area ranges from +1.75 in 2006 (wettest year) to -2.039 (Driest year) in 2015. Historical droughts in Ethiopia had been linked with ENSO events in the past (NMA, 2007). Recent documented droughts of, 1990–

1991,1999- 2000,2009 2012, 2015 were coincide with the results in the study period and believed to be El Nino events shortly (Amogne et al., 2018). The precipitation concentration index (Table 4) revealed the presence of a moderate (Annual and belg 12.39 and 11.69 respectively) and uniform .(Kiremt, 9.07) concentration of rainfall.

Table 5: Trends of annual and seasonal rainfall total at Hawassa (1987 to 2016).

Rainfall Characteristics	Trend		
	Z_S	Sen's Slope (mm/annum)	Intercept (mm)
Annual rainfall total	0.07^{ns}	0.439	955.78
Belg season total rainfall	0.79^{ns}	1.665	278.48
Kiremt season total rainfall	0.55^{ns}	1.817	416.94

Z_S is MK trend test; ^{ns} – non significant statistically at 0.1 probability level.

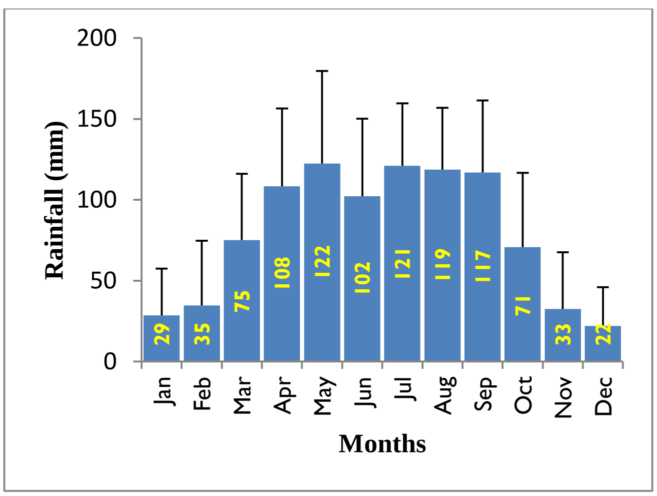


Figure *4*: Monthly rainfall distribution with standard deviation of Hawassa stations of 30 years (1987-2016)

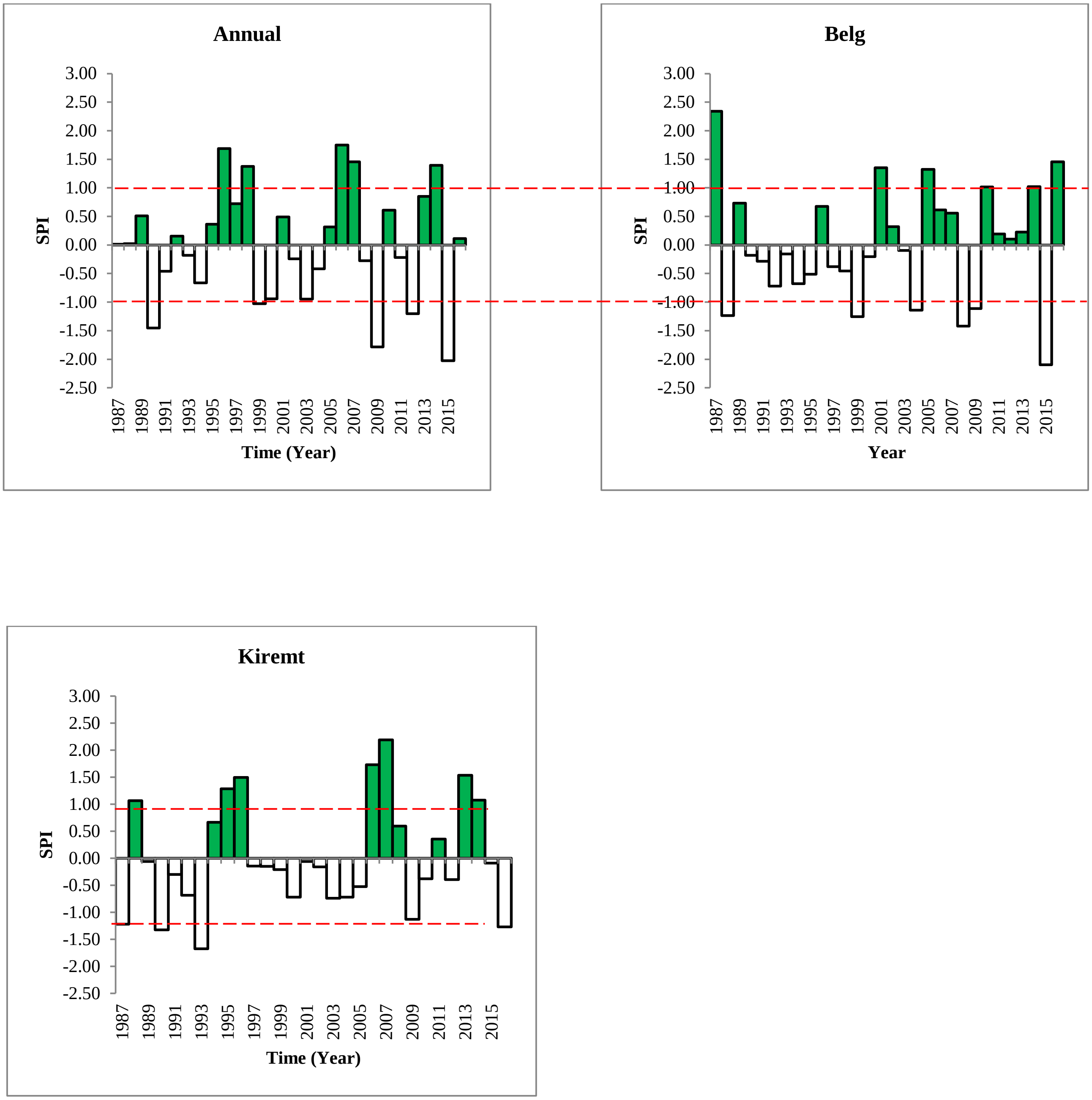


Fig 5 SPI for annual kiremt and bega season of the study area

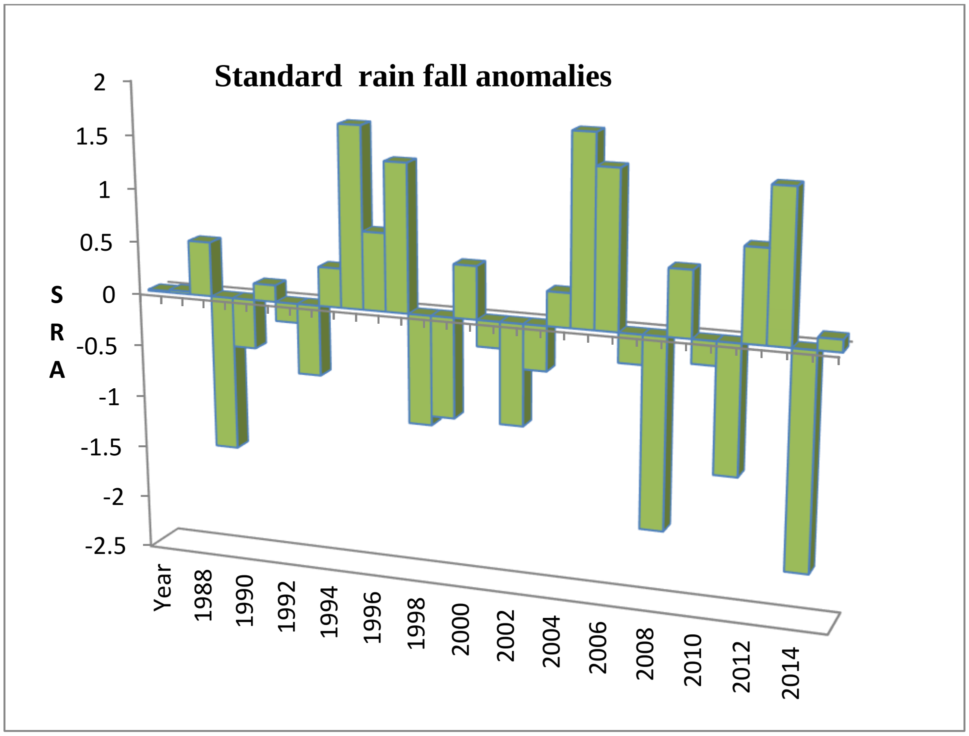


Fig 6 Standard rain fall anomalies of the study area for the period(1987-2016)data from NMA

4.2.2 Trend analysis result

The MK test and Sen's slope estimator (with double mass curve homogeneity test) were applied to the time-series data from 1987 to 2016 for Hawassa zuriya woreda. The results of MK test for trend analysis are presented in Table 5. The trend analysis has been done for, belg , kiremt seasons and the whole year. The results of MK test for monthly precipitation data indicates a statistically non-significant decreasing trend for the Annual averages rainfall. where as the belg and kremt rain fall (the major rain season in the study area) show, a statistically non significant increasing trend was observed. The output agrees with the result disclosed by Seyoum (2015); in the same district. The months May, July, Augest and September receive the higher average rain fall (122,121,119 and 117mm respectively), followed by April and June(108 1nd 102 mm respectively) and December receives the least one (22mm) (fig 4). One can see that the three months June, July and August receive more or less similar amount of rain fall(uniform) also agrees with SPI values <10 . The study, revealed that uniform but non-significant decreasing trend of annual average rain through time was obtained which coincides with Seyoum (2015) .The major problem, as far as rainfall distribution is concerned, as stated by elders in the FGD is not the amount rather the variability and change in different seasons.

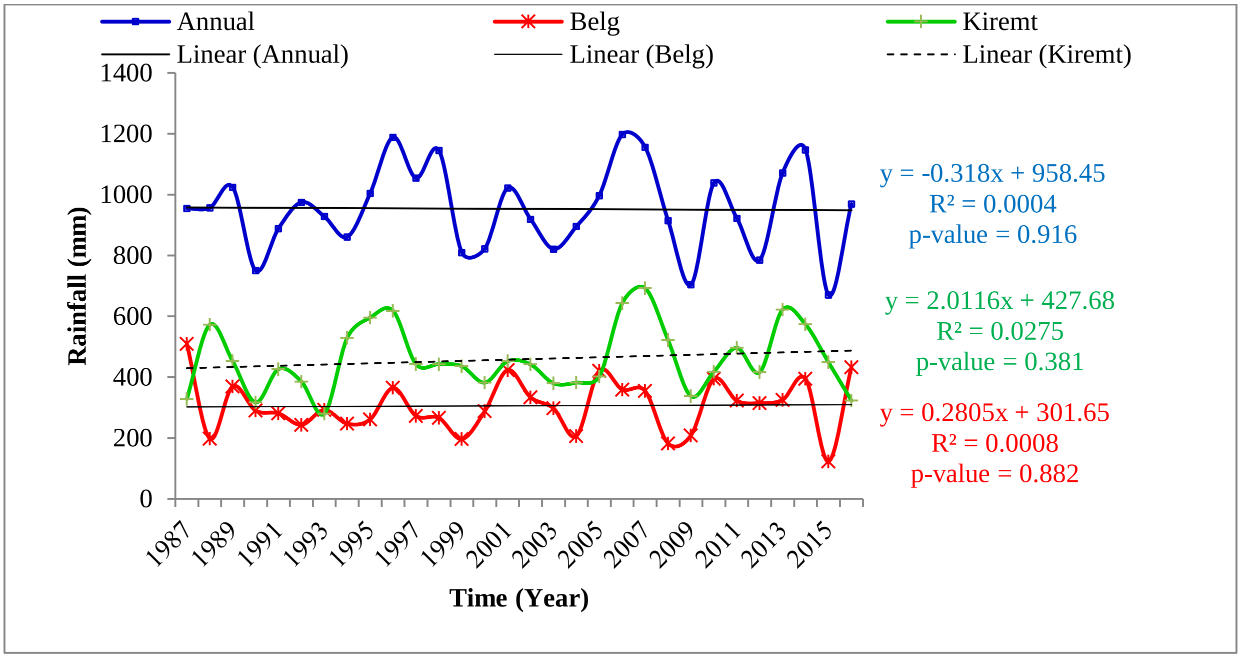


Fig 7 rain fall trends in the study area for a period 1987-2016 data from NMA

Rainfall during September (end of kiremt) is essential because the crops during this time are at flowering or ripening stage and require more water for maturation(Amogne, etal., 2018). Slight disturbance such as temperature fluctuations at critical points in crop growth can have considerable effects on later productivity (Amogne,etal., 2018).

4.3 Temperature trend analysis

An increase in temperature is a common phenomenon of climate change throughout the globe (Amogne, et al., 2018.) . Analysis of annual and monthly temperature data was conducted to detect the variability and trend of temperature change in Hawasa zuria district for the periods of 1987–2016. As shown on table 6 mean monthly and annual temperature (minimum, maximum and annual average) and its trend in the study period. The mean temperature in the study area ranges from 13.1^{0}C (minimum) to 27.4^{0}C (maximum) with annual average temperature of 20.25^{0}C. Using a linear regression model, the rate of change is described by the slope of the regression line (Fig. 8) which in this case is about 0.026 and 0.062 and 0.026 C per annum for mean maximum and mean minimum temperature respectively during the period of 1987–2016.

Table 6: Descriptive statistics of temperature at Hawassa station (1987- 2016)

Descriptive statistics	Annual	Seasonal	
		Belg(MAM)	Kiremt(JJAS)
Average annual temperature (^{o}C)	20.25	21.25	19.75
Mean Maximum temperature (^{o}C)	27.4	28.6	25.2
Mean Minimum temperature (^{o}C)	13.1	13.9	14.3

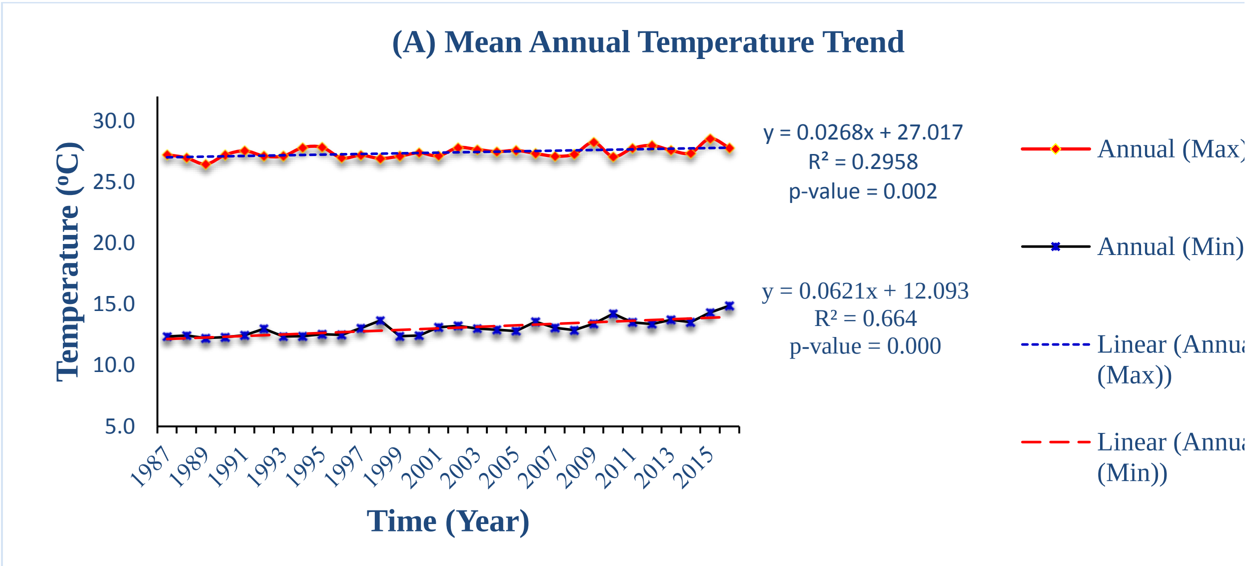
Source: NMA data

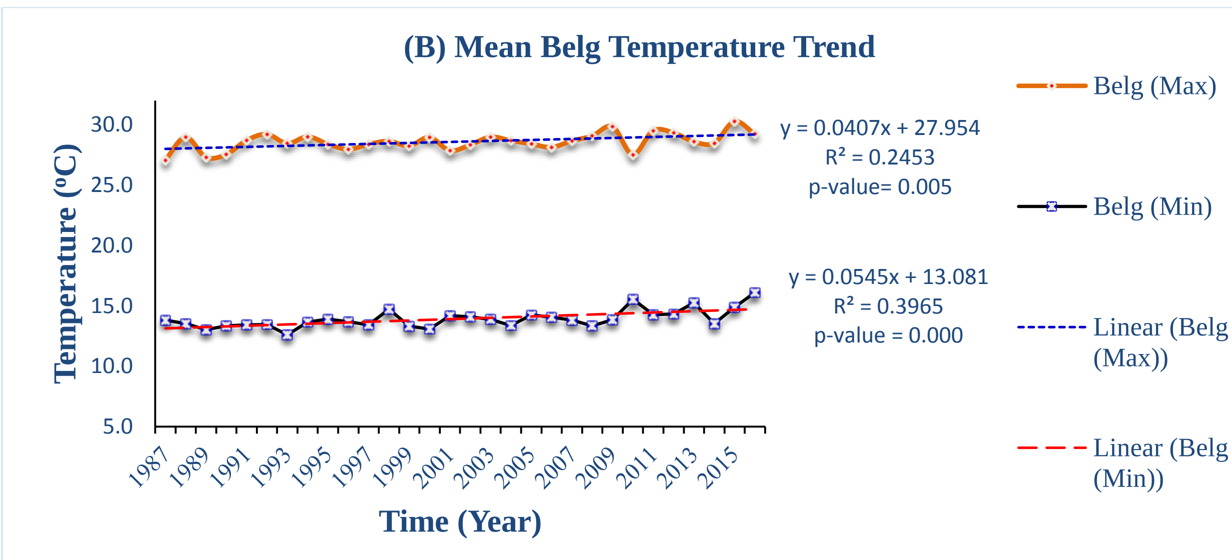
This also agrees with global warming rate which is estimated 0.6 ^{0}C for the past century(IPCC2007). As demonstrated in Table 7, MK trend test result revealed that annual minimum and annual maximum average temperatures have been increasing significantly at 99% and 95% confidence level respectively. The trend for Belg temperature showed the same result as that of the annual one ,belg maximum and minimum temperature showed significant increasing trend at 95% and 99% confidence level respectively. The Kiremt period temperature trend resulted in significantn increasing trend for both minimum and maximum temperture at 99% confidence level. The overall increase in annual temperature observed in the study area is attributed to an increase in the minimum temperature (the increment of the minimum temperature is more pronounced than the maximum). IPCC fifth Assessment Report WGII also found that recent reports from the Famine Early Warning Systems Network (FEWS NET) revealed that there has been an increase in seasonal mean temperature in many areas of Ethiopia (IPCC, 2014). According to the UNDP climate change country profiles, the average annual temperature in Ethiopia raised by 1.3^{O}C between 1960 and 2006 (Mc Sweeney et al, 2010). Daily temperature observations also show an increase in the average number of 'hot' days and 'hot' nights per year (Ibid). This is also perceived by farmers (69.8%) answering an increase in the trends of hot days in the last 3 decades.

Table 7: Trend of annual and seasonal temperature at Meribo (1987- 2016)

Season	Trend					
	Z_S		Sen's Slope (°C/annum)		Intercept (°C)	
	T_{max}	T_{min}	T_{max}	T_{min}	T_{max}	T_{min}
Annual	2.46^{**}	5.00^{***}	0.024	0.055	27.05	12.16
Belg (MAM)	2.28^{**}	3.35^{***}	0.042	0.045	27.99	13.23
Kiremt (JAAS)	3.03^{***}	5.14^{***}	0.031	0.054	24.70	13.51

Z_S is MK trend test; **, *** indicates statistically significant at 0.05 and 0.01 probability level, respectively; Tmax – maximum temperature; T_{min} – Minimum temperature Source: Computed from NMA data


(A) Mean Annual Temperature Trend
Temperature (ºC)
30.0
25.0
20.0
15.0
10.0
5.0
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Time (Year)
y = 0.0268x + 27.017
R² = 0.2958
p-value = 0.002
y = 0.0621x + 12.093
R² = 0.664
p-value = 0.000
Annual (Max)
Annual (Min)
Linear (Annual (Max))
Linear (Annual (Min))


(B) Mean Belg Temperature Trend
Temperature (ºC)
30.0
25.0
20.0
15.0
10.0
5.0
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Time (Year)
y = 0.0407x + 27.954
R² = 0.2453
p-value= 0.005
y = 0.0545x + 13.081
R² = 0.3965
p-value = 0.000
Belg (Max)
Belg (Min)
Linear (Belg (Max))
Linear (Belg (Min))

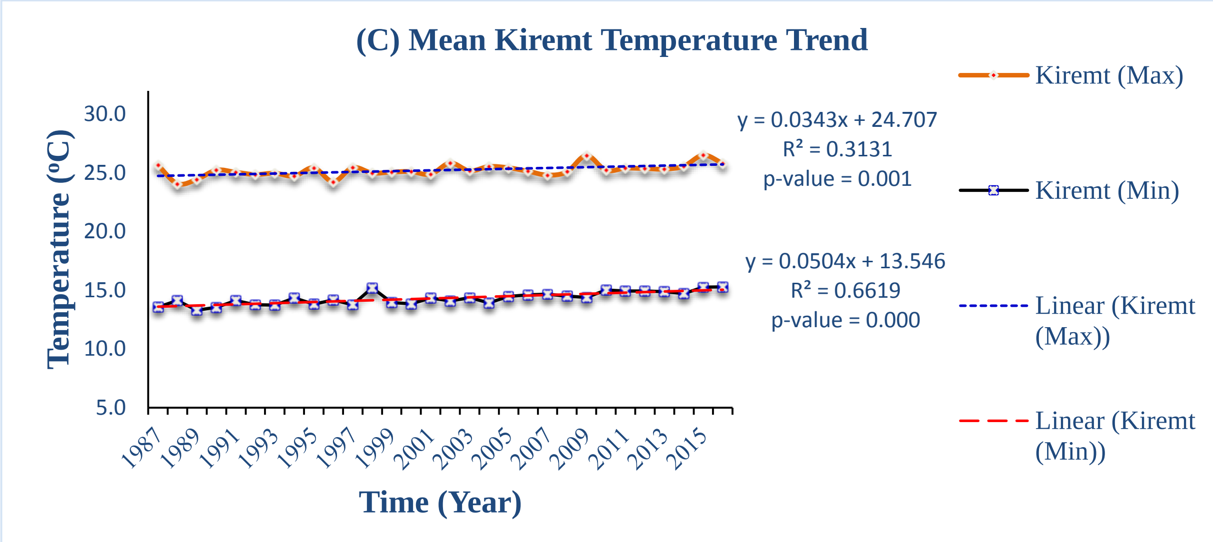


Fig 8: **Long-term (30 years) mean maximum and mean minimum temperature trend at Hawassa station Source: NMA of Ethiopia**

. The empirical result agrees with the views of respondents; particularly farmers in the study area have confirmed an increasing trend of temperature. According to Daniel et al. (2014) where the increasing trends in the Tmin series were higher than those in the Tmax series. Based on the gauge data, temperature trend (all minimum, maximum and anual) have shown a statistically significant increasing trend. Based on the responses of surveyed household heads (Fig. 9), the temperature condition in their locality has been increasing (78.6.1%) as compared with the situation before 30 years and the amount of rainfall has been decreasing (68.3%). This implies that the increasing trend of temperature has a stressor impact on crop production and other agricultural practices. If we look at the land management practices of the study area farmers prefer more heat resistant plant varieties and practices (like Enset, mulching,). Whereas high water requiring varieties like grass strip and broad lived tree species are not preferred. Therefore farmers are very wise in selecting practices that suit the prevailing climatic conditions.

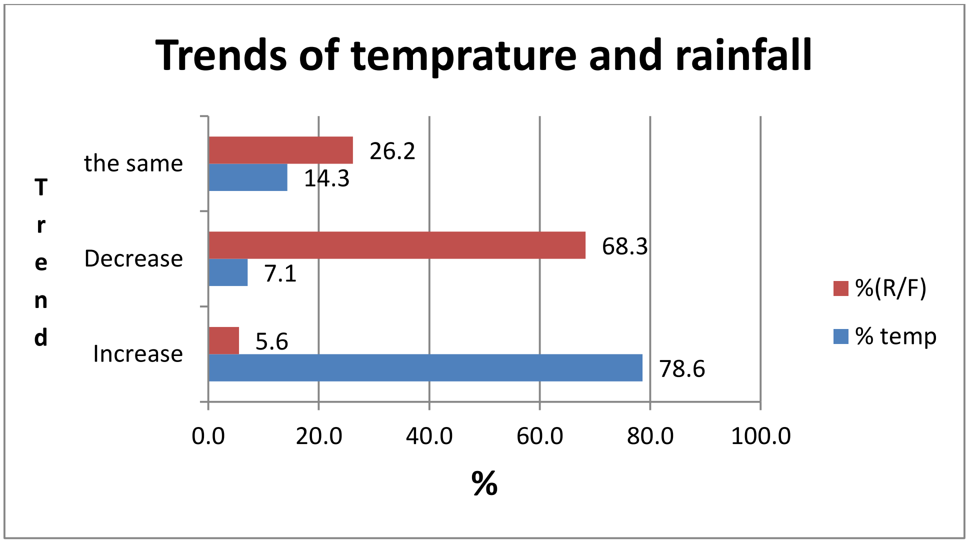


Fig 9 Farmers response of climate change : source own survey 2018

On the other hand 26.2% and 14.3of the respondents answer that the rain fall and the temperature is the same . This can be matched with the stable but the falling trends of rain fall in the study area and it is also non significant statistically as shown in (table 5 and fig7) the rate of change is small and may not be felt by some. Whereas some (5.6% and 7.1%) of the respondents answer an increase in rain fall trend and a decrease in temperature respectively according to the 1 FGD discussant he associated the increase of rainfall with incidence of flood and the last years occurrence of extreme coldness that killed some hyenas in the area. Even though this is not in line with the NMA result some farmers give due emphasis to the recent events. According to the surveyed households rainfall changes for the last 30 years as compared with before 30 years, rainfall currently onsets late and ends early as well its amount vary. Moreover, the majority of respondents (89.6%) have agreed on the presence of variability in volume and spatial distribution. Unprecedented hot days during kiremt or/and belg seasons has become a common phenomenon for the last 2 decades. Additionally, rainfalls are erratic and occurrence of drought ,flooding and manifestation of pests have been revealed in the last few years. As explained by elders, there is a shift in habitat and loss of bio diversity has been noticed in the area in the last 3-4 decades which is mentioned as an indicator for those climatic changes.

4.4 Land Management Practices in the Study Area(Obj,2)

Technically supported physical and biological conservation measures were slightly implemented to prevent soil erosion, land degradation and climatic hazards in the study area. The main purposes of those LMP measures were to control the movement of water over the soil surface and limit its erosive capacity and enhance productivity.

Table 8 Type of Land management practices(N=126)

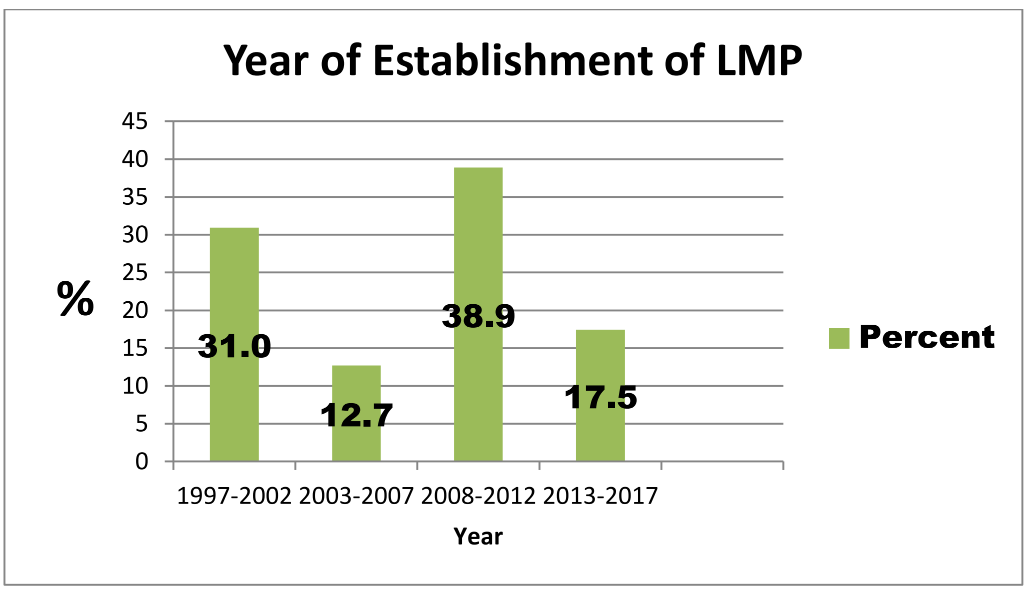
LMP	**Cumulative users of LMP(N=126)**		**LMP Status by specific practice**					
			Poor		Good		V.good	
	Freq	percent	Freq	percent	Freq	percent	Freq	percent
Grass strip	17	13.5	5	29.41	8	47.06	4	23.53
Soil bund	50	39.7	13	26.00	17	34.00	20	40.00
Agro forestry	112	88.9	26	23.21	27	24.11	59	52.68
Water harv.	11	8.7	6	54.55	2	18.18	3	27.27
Composting	92	73.0	11	11.96	29	31.52	52	56.52
Mulching	44	34.9	8	18.18	12	27.27	24	54.55
Cem.fertilizer	97	77.0	32	32.99	23	23.71	42	43.30

Tillage.practice	102	81.0	30	29.41	11	10.78	61	59.80
Irrigation	29	23.0	5	29.41	7	24.14	17	58.62
Cumulative(Over all status)	554	100	136	24.55	136	24.55	282	50.90

Source: field Survey 2017/18

As the data from the farmers, the main LMP implemented in the study area were soil bund, grass-strip, Check dams, area closure, composting, irrigation, mulching, agro-forestry , contour farming, exotic tree planting and chemical fertilizer application. Moreover, plantation of indigenous forest species as an agroforestry tree (Acacia species) is widely implemented in the study area (Table 8).

More over Table 8 shows a wide range of land management practices by the respondents in the study area. The table reveals that 88.9 % of the responding farmers practice agro-forestry (Enset based and mixed cropping together with livestock and trees), 81% practice conservation tillage (contour farming, BBM, row planting and minimum tillage). Another land management practice on the study is application of chemical fertilizer which has 77% response. The respondents said due to the stressing heat of the sun, the practice of mulching(34.9%) and leaving crop residue on farm become very important. The planting of leguminous crops (Harricot bean with maize is also) a common practice among farmers in the study area. Other practices are composting (73%), irrigating (23%), and soil bund (39.7%), Grasss strip (13.5)%. The above finding is in line with Yan *et al.,* (2009) who indicated that climate-smart farming practices improve rural livelihoods while mitigating and adapting to climate change. New crop varieties, crop rotations, composting, conservation tillage, cover (Mulching and crop residue) all increase carbon storage (Smith *et al.,* 2009). Crop rotation, mixed cropping and agro-forestry are promising practices. Thanks to agro-forestry and the combination of annual crops, trees and shrubs associated with it, a significant portion of on-farm energy demands can be covered (UNCCD, 2009). More over the current status and their year of establishment of those practices were also assessed. Fig 10 indicates that the establishment period of those LMP are in b/n the year 1997 through 2017. Most of them were implemented in b/n the year 2008-2012 which is associated with the recorded period of drought year throughout the country (the year 2009) according to the meteorological data it is the 2nd most driest year (fig 5 and 6), implying that climate extremes are driving forces for mitigative and adaptive responses.



Fig, 10 Year of establishment of LMP: source survey 2018

The second higher implementation period were between 1997-2002 is also the period of pronounced rain fall declining year as can be seen from Fig,6 of rainfall anomalies of the study area (1987-2016). When we come to the status of those LMP practices the survey result as well as the researcher observation indicates that more than half (50.9%) of those LMP are in good condition, the rest are in equal proportion of medium and poor condition

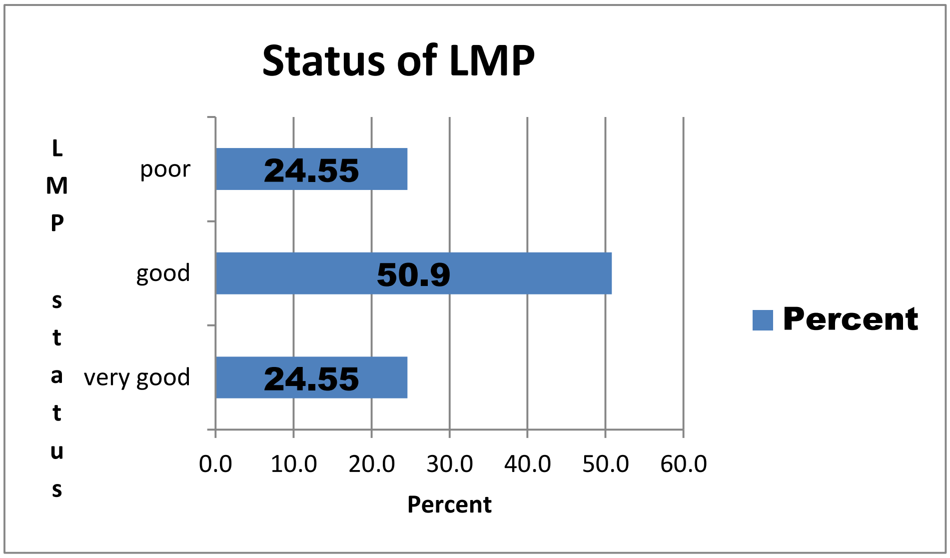


Fig 11 Status of LMP in the study area

(24.55% each).The general condition revealed that more than 75% of those practices were in a better condition implying that they are accepted by farmers. Whereas some 24.55% are in a poor condition indicating that either some farmers may be forced to practice those LMP or they lack resources for maintenance. Therefore and the extension approaches are need to be modified and priority should be given to those resource constrained farmers in order to meet the intended goals of those LMPs.

According to the survey result and the group as well as the key informant discussant the intended purpose of those LMP are to increase productivity, protect soil, enhance moisture availability, and to avoid risk of crop failure.(to be discussed i the benefit part later). this is also indicated in the CBPWD ,(2005) which states the main objective of watershed development is to: 1) conserving soil, rainwater and vegetation effectively for productive uses;2). harvesting surplus water to create water sources in addition to ground water recharge; 3). promoting sustainable farming and stabilize crop yields by adopting suitable soil, water, nutrient and crop management practices; 4. rehabilitating and reclaim marginal lands through appropriate conservation measures and mix of trees, shrubs and grasses, based on land potential; 5). enhancing the income of individuals by the diversified agriculture produce, increased employment opportunities and cottage enterprises, particularly for the most vulnerable, linked to the sustained use of natural resources.

4.5 Selection criterions of LMP among others (Obj.3)

Based on the findings from observation and the response from the sampled HHs the identified LMP were selected based on the pair wise ranking and criterions mentioned in table 2 of methodology part. The KII discussants were asked to rank those practices based on their importance and their environmental and socio economic benefit . The result of pair wise ranking indicates(table9) that irrigation use has primary importance followed by equal weight of agro-forestry and chemical fertilizer application. The third order is soil bund followed by compost making (table9) . In order to select the best practices based on environmental ,social and economic criterions KII participant were provided with the , table2 and the aggregate result give priority for use of irrigation , soil bund and agro-forestry practices gain in their importance order . It was very difficult to make choice between fertilizer application and agro-forestry practice which were given equal weight by farmers. to make the best choice based on environment, social and economic importance agro-forestry practice were given highest rank. In the pair wise raking fertilizer also get higher rank than soil bund but in the social and environmental context it gets the lower rank and the researcher from CSA point of view and its environmental friendly nature soil bund were given the 3rd chance to be selected.

Table 9 Pair wise ranking of land management practice by respondents

LMP	Grass strip	Soilbund/fanyaajuu	Agroforestry	WH	Composting	Mulching	fertilizer	Tillage practice	Irrigation use	Score	Rank
Grass strip	X	S	AgF	WH	C	M	F	GS	IU	1	5
Soil bund/fanyajuu	X	X	AgF	S	C	S	F	S	IU	4	3
Agro forestry	X	X	X	AgF	AgF	AgF	AgF	TP	IU	6	2
water harvesting	X	X	X	X	WH	WH	F	WH	IU	4	3
Compost making	X	X	X	X	X	M	F	TP	IU	3	4
mulching	X	X	X	X	X	X	F	M	IU	2	4
Chemical fertilizer	X	X	X	X	X	X	X	F	IU	6	2
Tillage practices	X	X	X	X	X	X	X	X	IU	2	4
Irrigation use	X	X	X	X	X	X	X	X	X	8	1

Source own survey 2018.

GS=Grass strip, S= Soilbund, AgF= Agro-forestry,WH=water harvesting, C=composting, F=chemical fertilizer, TP =T illage practice, IU= Irrigation use.

According to the data from the group discussants and interviewees, the above physical, chemical and biological soil and water conservation were implemented in the farm land. According to IUCN, 2009; these above practices were considered as climate change adaptation mechanisms. Based on the data generated from the survey and other sources the local communities implemented the above adaptation mechanisms.

Table 10 LMP and their respective rank as per farmers response

LMP	**Frequency**	**Percentage**	**Bio-physical benefit(frequency)**			**Socio-economic benefit(frequency)**			**Over all(weighted average)**	**Rank**
			H(3)	M(2)	L(1)	H	M	L		
Grass strip	17	13.5	3	5	9	2	4	11	M (1.55)	8
Soil bund (fanyajuu)	50	39.7	38	8	4	22	9	19	M(2.37)	5
Agro forestry	112	88.9	99	8	5	92	14	6	H(2.83)	1
water harvesting	11	8.7	9	2	-	7	3	1	M(2.32)	6
Compost making	92	73.0	84	6	2	72	16	4	H(2.82)	2
mulching	44	34.9	33	6	5	19	11	14	M(2.375)	
Chemical	97	77.0	17	22	58	64	26	7	M(1.92)	7

fertilizer										
Tillage practices	102	81.0	90	9	3	82	16	4	H(2.80)	4
Irrigation use	29	23.0	26	2	1	24	3	2	H(2.81)	3

H=High(3). M=Medium(2), L=low(1) the number 1,2 and 3 are weight given to each order.

As shown in table 9 and 10 and the criteria set in table 2 ,the following three practices are selected among others in order to see their effects, specifically on income and crop productivity as a role for climate change adaptation.

1) Agroforestry

Agroforestry is the dominant practice in the study area practiced by 88.9% of the surveyed HHs. Generally Sidama zone and HZW in particular are known for their traditional agro forestry practices. Agroforestry is a dynamic ecologically based natural resources management system that through integration of trees on farms and in the agricultural landscape diversifies and sustains production for enhanced social, economic and environmental advantages (Leakey, 1997). The definition constitute that: AF normally involves two or more species of plant (or plants and animals) at least one of which is a woody perennial; has two or more outputs and more complex structurally as well as functionally and economically, than a mono cropping system(Ibid). Main agro-forestry practices in the study area include, home gardens, park land, isolated tree growing multipurpose trees and shrubs on farmland, boundary planting, farm woodlots, live fences, trees on pasture and apiculture with trees. Trees and shrubs in farming systems can play a significant role in climate change mitigation and adaptation as they have a higher biomass per unit area than, for example, annual crops or grasslands(Terr Afric, 2009). In addition to benefits such as the provision of wood and non wood forest products (NWFPs), restoration of soil fertility and the conservation of biological diversity, trees and forests improve the microclimate by buffering winds, acting as a barrier against extreme weather events (wind, heavy rain / hail), regulating the water table and providing shade to crops and animals. They are, therefore, part of sustainable agricultural production systems, contributing to both climate change adaptation and mitigation(Terr Afric, 2009). According to group discussants increased yields of food crops (Enset,Haricot bean) including tree crops(Coffee), have contributed for food security. Other non-woody forest products (medicinal plants(Moringa), fruits(Mangoe), fodder(Sesbania,elephant grass), wood for fuel and timber) have wider household benefits and generated additional income, stimulating rural economies. According toICRAF 2009 the adaptive potential of agroforestry is ranked as 'high' in sub saharan african region as compared to the 'medium' ranked chemical fertilizer usage indicating its potential even better than any other LMPs. According to Kim ,(2016) agroforestry (at an average age of 14 years) sequestered 7.2 t C/ ha/ y, with biomass C sequestration contributing about 70% and soil C sequestration contributing about 30% of the gross gain(Ibid). Soils under agroforestry also oxidised 1.6 ± 1.0 kg CH4 /ha / yr and emitted 7.7 ± 3.3 kg N2O/ ha/yr (Kim 2016). Compared with adjacent agricultural fields, soils under agroforestry had lower bulk density (good aeration and infiltration capacity) helps in reducing erosion and enhance moisture availability and higher SOC and soil N contents (reeduced chemical fertilizer needand increase yield), but pH and net CH_4 and N_2O emissions from soils under agroforestry remained nearly the same as under agriculture. Overall, young agroforestry stands contributed to mitigating 27 ± 14 t CO_2 eq /ha/ yr. Agroforestry is a key approach in the integration of climate change adaptation and mitigation objectives, often generating consderable co-benefits for local ecosystems and biodiversity, and should be expanded in the voluntary and compliance C markets (Matocha et al., 2012).Therefore the importace of agroforestry is not only for adaptation but also in mitigation of climate change. Agro forestry systems are most extensive in developing countries where about 1.2 billion small holders depend directly on a variety of agro forestry products and services (Leakey & Sanchez, 1997). a case study conducted in five sub-Sahara African countries, agro forestry is shown to have potential to increase farm incomes and solve difficult environmental problems. It is monetarily more profitable to local farmers in comparison with traditional cultivation, in addition to its other economic and social benefits. Thus, it can be a potential alternative cultivation practice that helps to reduce poverty and transition to permanent cultivation.

2) **Composting**

The second choice among other practices is application of compost on farm land and homesteads. According to group discussant and interview results some 73% of respondents apply compost in their farm as a fertility improvement measure. The discussant from focus group and key informants also added that using compost maintains the land productivity and lowers the fertilizer demand. From this one can understand that application of compost reduces the cost of chemical fertilizer therefore it has economic implication on top of productivity as well .The other important thing mentioned by discussants here is that the land with compost have more fauna than that of non composted ones, implying that enhances soil physical property by creating pore spaces and enhancing nutrient cycling. According to (FAO, 2013a) the cereal yield per hectare has increased since 1989. Between the time period

1991 to 2004 the average harvest were around 800 Kg/ha. During 2008 and 2011 the average yield had increased to more than 1200 Kg/ ha. The area used for cereal production has also increased between 1993 and 2012 (FAO, 2013a). Comparing the harvested area in 1993 with the harvested area in 2012 the area has almost doubled in size (FAO, 2013a). The total production of cereals is two and a half times greater in year 2012 compared to 1993, in the same period the LMP are implemented throughout the nation. So it can be understood that the yield increase is attached to not only the expansion of the land and the use of improved inputs but also due to those LMP. In terms of total cereal production there has been a tremendous increase. Farmers are very cautious in evaluating their farms production and productivity some 68% of respondents say that their production has increased by at least 1.5 Qt since the beginning of compost application assuming other things being constant. Whereas those who do not apply compost in their farm replied no change in their production level. Therefore composting have also economic and environmental importance as well which ultimately contributes to resilient agriculture and to climate change adaptation.

3) **Irrigation**

The result from the survey indicates that 23% of the households were practiced irrigation. Irrigation in the area led farmers to grow diverse spices and crops (pepper , vegetables like cabbage, onion and tomatoes) during the dry season. The average income of irrigation users has raised from 12000 ETB to 42,000 ETB. This change was consistent with the study in other part of the country by Meaza, (2015) indicated that various treatments carried out in the irrigated land helped to bring remarkable changes in the household’s livelihood. The proportion of area under irrigation in the study area is low as compared to the available land this is because of shortage of water and capital for motor pump purchase and to dig deep well.

Only farmers around the lake shore practiced irrigation and diversify their crop activity which resulted in increase in high value crop including vegetables and spices .Water sources used for irrigation purpose were shallow well and lifted up by using rope and washer pump as well as motorized pump. Utilization of Water lifting technologies is considered as an advantage to ensure economic, social as well as environmental well being a well as food security in the area. As one uses irrigation he becomes more secured and resilient in terms of food and income.

Table 11 Benefits generated from LMP(N=126)

LMP Benefits	Frequency	Percent	Overall Rank(by each practice)
Protects soil	90	71.4	4
Increases crop yields/food product	110	87.3	2
Enhance nutrient recycling/fertility	80	63.5	5
Assurance of food security	114	90.5	3
Preserves soil moisture	89	70.6	3
Speeds soil microbial activity	67	53.2	4
Aids soil aeration	61	48.4	5
Reduce flooding /water runoff	97	77.0	3
Improves soil property/structure	95	75.4	6
Maintains healthy ecosystem	99	78.6	4
Reduce_risk_of cropfailure	117	92.9	1

Mitigate_soil_degradation	98	77.8	3
Improve_the_provision_of_local_energy	98	77.8	6
Other	77	61.1	7

From table 11, one can see the many benefits of land management as indicated by high percentage responses. The foremost benefit of land management is the assurance of food security ,reducing risk of crop failure, increase of yield at a response rate of 90.5%, 92.9%, 87.3% respectively. These benefits are generated from the use of irrigation, application of chemical fertilizers and construction of soil bunds, agro-forestry practices and composting. More over maintenance of healthy ecosystem(78.6), mitigation of soil degradation(77.8), improve the provision of local energy(77.8), preservation of soil moisture(70.6%), enhancement of nutrient cycling (63.5) are the other most benefits generated from different land management practices mentioned in table,9. The above finding is also in agreement with UNCCD (2009) that maintaining ecosystem functioning is a prerequisites for sustainable land management. Land management practices have great potential for preservation and enhancement of ecosystem services in all land use systems. properly implemented and maintained land management practices limits soil degradation, water and vegetation depletion. More over the benefits of those LMP are ranked based on the counts from each practices. Farmers were asked to give ranks for each of the benefits of LMPs in their farm land. The overall ranking indicates that reduction of crop failure, increase in crop yield, and improvement of soil moisture are given 1^{st},2^{nd} and 3^{rd} ranking order respectively the rest of them holds the ranking order 4^{th} through 7^{th} with some of the benefits having equal ranking order based on count. This imply that some benefits generated from different LMPs are equally important.

Adaptation

Implementing LM practices that increase carbon sequestration like agro-forestry, composting and mulching in soils will contribute to adaptation to climate change(Terr Afric ,2009). Increasing Soil organic carbon well known for its multiple benefits for the soil (Lal, 2004a), including: (i) increasing fertility through nutrient retention; (ii) enhancing rainfall infiltration rates; (iii) improving water holding capacity; and (iv) improved environment for soil fauna and related macro-pores such as termites, earthworms, and root channels to serve as percolating channels for excess water. Thus, stabilizing a much improved soil structure increases “the resilience of the land”(Terr Afric,2009).

The surface mulch or plant cover established under several LM practices also protect the soil from excess heat and evaporation losses(Ibid).

Roles of Land management on Economic, social and Environmental development

Considering the potential impacts of land management are indicates contribution to cope with climate change influences. According to MOARD, (2005).Land management contributes to all sectors (agriculture such as crop production and livestock, water availability and quality, health, ecosystem service, socio economic and all human livelihood activities) directly or indirectly via chain reaction available among sectors.

Effects on Crop Production and Income

Crop is the most important source of household income in the study area. The main crops in the study area were maize, Enset, Chat, Coffee and tobacco 60%, 20% and 20% of the respondents revealed that crop was contributes 70%, 50%and 40% of their incomes respectively. This indicates that most of the households were dependent on crop production as primary source of their income. Due to the different land management interventions the productivity of most of the crops were increased and in turn increased the household's income (see table 12).

Table 12 Income before and after intervention of LMP

Before Land management (1997)			**After Land management (2017/18)**		
Crops	Average production in Qt/ha/yr	Average Income(birr)	Crops	Average production in Qt/ ha/yr	Average income(birr)
Enset	40	24000	Enset	44	26400
H/bean	8	4000	H/bean	12	6000
Maize	40	20000	Maize	48-50	25000
Chat(Khata edulis)	20	12000	Chat(Khata edulis)	26	15600
Coffee	3	6000	Coffee	4	8000
Pepper	-		Peper	25	**25000**
Vegetable	-	1000	Vegetables		10000
Total	**111**	67000	-	**159**	116000

Source Own survey 2018

Qt = quintal =100Kg

Due to the mulching, irrigation , agro-forestry practices and other SWC structures, increased moisture and soil fertility have improved productivity resulting similar increase in area and production of important crops (vegetables, chat and others). The farm area, productivity and production of important crops during the period of land management (1997 to 2017) in the district were increased. The survey indicates crop production were higher after the intervention compared to before the intervention in the study area and income from and average crop production of surveyed households increased from 111Qt to 139Qt and 67000 to 91000(excluding pepper) birr respectively(Table, 12). According to the sampled households and group discussants and interviews, the increasing in crop production and income were attached to the land management activities like soil bunds ,agro-forestry, irrigation, mulching and tillage practices.

Similarly, food availability of the households was improved due to the different conservation measures and application of improved agricultural inputs. As the survey data revealed, before the intervention 64.7% and 88.9% of the households harvest was able to cover the household's food demand for 8-12 and 10-18 months respectively especially in the irrigated areas. This implies that LMPs are a very important measures for food security and livelihood improvement and ultimately to adapt to the changing climate..

Effects on Employment Opportunity

The Land management practices in the study area creates households with different employment opportunity. The farmers in the area are well organized and increased working duration as far as they are thirsting to get good return. Households were involved in irrigation, petty trade activities and to begin new income source such as bee keeping and fishing by learning from their past and their neighbors. Working culture of households was changed they are involved in work for food activities as well as free labor contribution for 30 days annually for those LMP as part of watershed development campaign by the government. They also get experiences from those food for work activities and project funded daily labor works for LMPs and they migrate in to the nearby city of Hawassa and get additional income as a daily laborer. This again reduces their vulnerability by diversifying their income source other than climate sensitive agriculture.

Effects on Social Interaction

Improving social interaction of land owners was also the important benefit the land management practices fetch. The government introduced 1 to 5 household's organization which have a considerable role to enhance household's social interaction and adoption of new technologies. It was applied on the assumption contact and follower approach .that means if one farmer achieves a success on a given LMP technology , the neighboring farmer may learn the technology from the contact(model) farmer, and share with others, thereby developing a multiplier effect. Social interaction was from model/role farmers who acted as mentor to the other farmers. Similarly, the respondents and key informants as well as group discussants witnessed that this communication improves household's involvement in different activities by making good learning and teaching environment each other.

Therefore, land owners and communities were better able to cope with climate extremes by a multiplier effects those interactions having on their land's better management and hence on their productivity as well as income.

Climatic Effects in the area after LMP

The responses from the group discussant key informants and interview indicates that due to the different LMP implemented, there had been betterments in land management and utilization in the study area and in return reduced the impacts of climate related risks. The response indicates that 60.7% of households consider drought as decreased in the study area after the introduction of those LMPs. Whereas 28.5% and 10.8% of households say that increased and no change respectively. About 75% of households ranked the flood hazards after intervention as less severe and not severe and also perceived its trend as decreased. about 61.1 % of respondents also perceive that the crop productivity due to those LMP is increased and the damage due to drought and flood had reduced(62.3%). As discussed earlier households perceived the impacts of climatic extremes before LMP as very severe and sever. But after intervention seeming as moderate and less severe. From this it is understood that the land management practices benefit highly reduce impacts of climatic extremes. These improvements were consistent with the Study for Ethiopia conducted by Assefa A. (2011) examined the role of watershed management for climate change adaptation which were found that as a result of the land management livelihood resources especially; income, soil fertility, land productivity, forest, water and food supply become improved but the achievement is not sufficient as compared to the success from other parts of the country. These all developments enable households to cope with climate change impacts. In 1998, there were 6% irrigated land while in 2017 it reached 23% (HZWOA and survey result). In spite of 17% increase in the number of irrigated land in the last 20 years; still not sufficient and equitable. Only those who reside around the lake shore uses irrigation . Moreover, according to the discussants and interviewees, the biological and physical soil and water management practices were great contribution to surface and ground water availability. There is still problems of drinking water scarcity in the study area before as well as after land management. Moreover, peoples walk long distance to fetch drinking water since the due to water shortage this implies that further improvement based on problem oriented study of LMP is required in order to satisfy all HHs in the study area. According to group discussant key informants and interviewee farmers, the implementation of soil conservation and water harvesting structures were highly contribute to increase access to irrigation. The survey result revealed that 23 % of the households were practiced irrigation. Irrigation and the introduced packages led farmers to grow diverse, crops (like vegetables (cabbage), potatoes, onion and tomatoes) during the dry season. Farmers' income from this activity highly increased from 16,000 ETB to 45,000 ETB. This is income in addition to their traditional rain-fed farming during the rainy season. The proportion of area under irrigation was increased as a result beneficiaries could diversify their crop activity which resulted in increase in high value crop including spices and vegetables. Water sources used for irrigation purpose were shallow well and pumping from the lake, which have not constant flow. The method of irrigation practiced by most of the farmers was shallow well by means of motor pumping to irrigate their farm. Water lifting technologies utilization is considered as an advantage to ensure food security in the area. The more the use of irrigation the more food secures likely and thus resilient households(Meaza,2015).

5 CONCLUSION AND RECOMMENDATION

As it is indicated from meteorological data as well as from farmers perception climate change is real and affects all aspects of livelihood, food security and general welfare of human in the study area. To adapt to climate change especially in the agricultural sector, practices like mulching/cover cropping, irrigation, SWC, mixed cropping be adopted by farmers. Adoption of and practice of land management have a lot of benefits such as increase yield, protection of soil ,aeration and gentle flow of underground water, avoid risk of crop failure. This research was aimed at assessing the effects of land management practices to climate change adaptation in two kebeles of Hawassa Zuriya district (Jara Hinessa and Jara Damuwa). The data collected from 126 households randomly selected from the aforementioned two kebeles. The government, NGOs and local communities implemented many LMPs in the study area to adapt with climate change, such as; Physical soil and water conservation measures like soil bund, composting, row planting (tillage practice), and shallow well for irrigation, dissemination of chemical fertilizer, agroforestry, irrigation practices. These different LMP were enabled to improve crop productivity, moisture availability, livelihood diversification, income, employment opportunity, conservation of degraded lands and minimizing the risk of climate changes have enhanced household's ability to cope up with climate change in the study area. In addition to these, the occurrence of impacts of climatic extremes in the study area such as flood, drought ,erosion, high temperature, prevalence of malaria and other plant and animal diseases were perceived as less sever and not severe after the intervention of those LMPs. However in the investment of these LMPs some challenges were facing such as shortage of land and natural rainfall variability and rising temperature, in adequate irrigation coverage due to water shortage. Based on the premises of the findings of this study the following are recommended to reduce the challenges and increase the benefits of those LMPs

- The LMPs in the study area are not sufficient in terms of coverage as well as maintenance therefore attention should be given to disseminate and to maintain the damaged ones.
- In order to enhance the water availability for irrigation and other uses gully rehabilitation, area closure and roof water harvesting and pond construction with proper care is necessary.
- The sensitive area of the lake shore requires serious attention. Delineation of buffer zone and construction of check dams in order to avoid contamination of agrochemicals and siltation problem is necessary.
- Family planning as well as campaign to initiate farmers to go to both formal and non formal education is needed
- Alternative means other than agriculture for livelihood condition is necessary (Fishing, beekeeping, petty trade, vocational training etc)
- Early warning and strengthening institutional capacity is also needed.

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Appendices

Anex 1 Questionaire

A) Household Survey

I. General information

1. Address: Name---------------- Wereda-------- --Kebele: ----------Village: ---

1.1 Demographic and socio-economic characteristics

3. Sex? 1. Male 2. Female

4. Age? 1. below 35 years of age 2. 35 -65 years 3. Above 65 years of age

5. Marital Statuses: 1. Married--2. Not married--3, Divorced 4, Other (specify)----

6. Educational level? 1. Illiterate 2. Read and write 3. Primary School 4. Secondary School, 5. Graduate

7. Family size? _______, Of these how many falls:

1, below 15 years of age (children)?___________.

2, above 15 and below 65 years of age (adult)? ___________.

3, above 65 years of age(old)?_________

8. How much money you earn per year in Ethiopian birr (ETB) (approximately)? _____

9. If you liquidate all of your private properties, how much capital (in terms of monetary value) will you have? ___________

10. With this total capital, in which socio-economic group do you put yourself?

1. Rich 2. Medium 3. Poor

11. How do you make your life? 1. Cattle rearing 2. Crop production 3. Mixed 4. Other (specify)---------

12. Do you own land? 1. Yes 2. No

13. How sloppy is your farm 1, plain 2, Medium 3, very steep

14. If your answer to the above question is yes, how much in ha is

1. the cultivated area:__________.

2. grass and woodland:_________.

3. parcels/homestead:_________.

15. What type of agriculture do you practice? 1. Rain-fed 2. Irrigated 3. Mixed

16. Why do you do farming? 1. Subsistence----------2. profit making(business)---

17. How long have you been farming? 1.Short (0-10 yrs) 2. Medium (10-30yrs) 3.High(30 +)

18. What power do you use for farming? 1. Family labor 2. Shared labor 3. Animal traction 4. Tractor 5. other(specify)----

19. In which category do you classify your soil on basis of its fertility? 1. Infertile 2. Less fertile 3. Fertile 4. highly fertile

20. How productive is your land without fertilizer? 1. High 2. Medium 3. Low

21. What type of grazing system do you use? 1. Communal grazing land 2.individual grazing Land

22. If you have individual grazing land, how much timad is it? ________

1.2, Institutional factor

23. Do you have agricultural extension services in your area? 1. Yes 2. No

24. Do you have access to information media? 1. Yes 2. No. If your answer is yes, which medium do you posses? 1. Radio 2. TV 3.journal/newspaper 4.extension agents 5.Other (specify)----

25. Do you have access to credit? 1. Yes 2. No

26. Do you have market access nearby? 1. Yes 2. No

27. If your answer is yes, how far is it? _________km(approximately)

28. Do you have roads of vehicle that connect you with nearby towns or cities?1. Yes 2. No

29. Do you have health centers at your village? 1. Yes 2. No

30. Do you have education centers at your village? 1. Yes 2. No

31. Is there electric services in your village?1.yes 2.No

32. If your answer to the above question is yes, what is the source of the power? 1.water 2.sun 3.bio fuel 4.wind 5.other(specify)-----

33. Do you have off-farm or non-farm income sources? 1yes 2.No

34. If yes, mention some of the major sources(petty trading, remittance, salary ,etc)

35. Do you own land holding certificate? 1.Yes 2.No

36. Can you rent out your land for 10 or 20 years? 1. Yes 2. No(explain to your answer)

37. Can you convert your cropping land into wood lots which production is possible after 5 or 10 years? 1. Yes 2. No(please give explanation to your answer)

38. Do you have access and use improved production inputs and technologies? 1Yes 2. No

1.3, Climate Change Assessment

39. Is today’s weather the same as the weather conditions that were 30 years from now?

1. Yes 2. No

40. What do you say about the trend of hot days over the last 30 years?

1. Increase 2. No change 3. Decreased 4.the same, but with altered climatic range 5. I don’t know 6. Other (specify) ---------

41. 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 are not familiar to the area(malaria etc)

2. Introduction of plant and animal species that were 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, dry up of rivers , streams, lakes, dressing light cloths etc)

4. Habitat shift towards higher locations

5. Other(specify)

42. What do you say about the trend of precipitation over the last 20 years?

1. Increased 2. Not changed 3. Decreased 4.change in times of raining

5. Increase in frequency of drought 6. I don’t know 7.Other(specify)

43. Which local indicator do you use to evaluate today’s rainfall pattern?

1. Loss of some plant and animal species

2. Increased drought and flood frequency

3. Growing period shortened

4. Rainfall come early or lately

5. Decline of soil productivity/fertility

6. Decline of agriculture yields

7. Decreased available water

8. Other(specify)

44. Have you heard of the word “climate change” before? 1. Yes 2. No.

45. If yes, when? __________

46. from which source you heard about climate change?(multiple answer is possible)

1.Television (TV) 4. radio

2.newspapers 5. school/college

3.friends/ families 6. government agencies/information

7.other (specify)

47. What do you think is the cause of climate change?

1. human actions

2. natural process

3. Both human action and natural process

4. I don’t know/I have no idea.

48) Who are the people seriously affected by climate change? A. The poor B. The rich

49) The threat of climate change is more on;

1. Health 2. Food production 3. Fuel wood availability

4. Businesses 5. Prevention of disasters

50) : What are the strategies to adapting to climate change?(tick rank in the box V.High, High medium and low)

a. Planting Different Varieties of crops □ □ □ □

b. Different (staggering) time of planting □ □ □ □

c. Rearing different breeds of livestock □ □ □ □

d. Soil fertility and water management □ □ □ □

e. Feed preservation □ □ □ □

f. No adaptation method used □ □ □ □

II. LIVELIHOOD STRATEGIES

2.1. For how long did you live here? [1] 5 years [2] 6-10 years [3] 11-25 years [4] >25 years

2.2. Would you like to continue to live here anymore? [1] Yes [0] No [3] I have no idea [3] I am planning to leave after sometimes, why? ____

2.3. What is your major livelihood activity?

[1]Agriculture [2] Off-farm activities [3] Non-farm activities [4] All side by side

2.3.1. Why you select this livelihood activity? ____

2.4. If agriculture is your major livelihood activity for how long did you work on agriculture?

[1] Less than 5years [2] 6-10 years [3] 11-15 years [4] 16-20 years [5] >20years

2.5. Which farming system are you following currently? [1] Only crop production [2] Livestock raring [3] Mixed farming (Crop production and livestock raring)

2.6. Have you change farming system in the past 5years? [1] Yes [0] No

2.6.1. If yes for Q.2.6. What are the changes? ____

2.6.2. If yes, Q.2.6.Why did you change the farming system you were following?

[1]Decrease in rainfall [2] Drought [3] Decrease in productivity of livestock

pest and disease [7] others ____

III. LAND AND OTHER NATURAL RESOURCES

3.0. Land ownership

3.1. Do you have plot of land? [1] Yes [0] No

3.2. If yes, for Q3.1 what is the total landholding in timad? ____

3.3. What is the area of land allocated for [1] Grazing land [2] Arable land ____

[3] Forest land [4] Fallow land [5] others__________

3.4. Is the land you have enough to produce for your household consumption?[1]Yes [0] No

3.5. If not, why ____

3.6. Do women have equal right over land and land related resources in your village? [1] Yes [0] No

3.7. Have you ever invested on your available land to increase its productivity? [1]Yes [2] No

3.7.1. If your answer for Q.3.7 is yes, could you please mention the investments you have made so far?

[1] Biological Soil conservation [2] Physical soil structure [3] Water storage structure [4] Planting trees [5] Application of chemical fertilizer [6] using compost [7] Irrigation canal

3.7.2. If the answer for the Q.3.7 is no, what are your reason(s)?

[1] Shortage of capital [2] Shortage of technical support [3] Short of knowledge [4] Inaccessibility of farm inputs [5] Inappropriate land use policy [6] Poor credit service

3.8. Do the existing land use policy influence investment on land? [1]Yes [2] No

3.9 What are the Land management practices in your Farm Land and who introduce it (mention specific practice eg. grass strip, soil bund etc)

[1] Biological Soil conservation [2] Physical soil structure [3] Water storage structure

[4] Planting trees [5] Application of chemical fertilizer [6] using compost [7]

Irrigation canal [8] other specify

3.9.1 List the practices by their specific name

3.9.2 who introduced these practices (Government, indigenous,NGO,SLMP.....)?

3.9.3 when was it introduced/implemented?

3.9.4 who supported you in implementation of it?

3.9.5 What is the current status of the LMP ?(evaluate each ,poor, good, v.good)

4.0) Benefits generated from Land management practices

4.1) What benefits do the introduced as well as existing land management practices have?

benefits(tick for each practice listed in 3.9))

a) Crop residue protects soil

b) Increases crop yields/food product

c) Enhance nutrient recycling

d) Assurance of food security

e) Preserves soil moisture

f) Speeds soil microbial activity

g) Aids soil aeration

h) Improve gentle flow of water in soil

i) Reduce flooding /water runoff

j) Production of diseases/pests resistant seeds

k) Valorization of indigenous knowledge

l) Producer crops that adaptation to harsh weather

m) Improves soil property/structure

n) Maintains healthy ecosystem

o) Reduce risk of crop failure

p) Reduces atmosphere carbon dioxide

q) Mitigate soil degradation

r) Enhance ecotourism

s) Improve the provision of local energy

t) Reconstitute carbon pool in soil

u) Keeps alive cultural/natural landscape

v) other specify

4.2) Rank the above benefits for each practices (as 1 ,2,3...)

4.3) is your income increase or decrease as a result of increase or decrease in crop yield and by how much? how do you measure it?(monetary or amount of yield?)

5. About crop production

5. 1. Do you produce crop? [1]Yes [0] No

5.2 What crops you produced in 2017/18 cropping season?

No	Type of crop	Area covered(Ha)	Qty. produced/ Quintal	Use chemical fertilizer(kg)	Source of input
1 Teff					
2 Enset					
3 Maize					
4					
5					
6					
7					

5.3. What are criteria used to select crops for production?

[1]Drought tolerance [2] Pest and disease tolerance [3] time it takes to mature

[4] Market value [5] Productivity [6] others, specify __________

5.4. What do you think is the trends of your crop production in the past 5-10 years (rank)?

[1] Productivity (yield) decreased [2] Change in type of crops grown [3] Productivity (yield) increased [4] Crop diversification increased [5] There is

no change [6] other

5.5. What would be the reason/s/? ____

5.6. Have you ever used improved crop variety in the last 5 years? [1]Yes [0] No

5.6.1. If your answer for Q.3.2.6, is no, why?

[1] Insufficient farmland [2] shortage of capital [3] poor credit service [4] Absence of improved variety [5] I suspect its productivity [6] Demands extra management [7] Others (specify) ____

6. Income

6.1. What is the total estimated annual expense of your house hold? Et Birr

6.2. What are the major expenses areas of your household in ranking order? ____

6.3. What are the major sources of your income?

[1] Crop sale [2] Sale of livestock [3] Off-farm activities [4] Non-farm activities [5] All [5] others

6.4. If non-farm activities are used as income sources, indicate which one you use most?

[1]Casual work/sale of labor urban [2] Retailing goods [3] Salaried worker [4] Remittances [5] house rent [6] others (specify) ____

6.5. If off-farm activities are used as income sources, indicate which one you use most?

[1]Working in paid on others' farm [2] Grain retailing [3] Retailing livestock [4] Selling fuel wood/charcoal/timber/grass/dung [5] Petty trade in the village

6.6. What is the estimated total amount of income of the household in Ethiopian birr in 2017/2018 E.C?

[1] Income from farming /year [2] Income from off-farm /year

[3]Income from non-farm /year [4] Income from other /year

Checklists to Guide Key Informant Interviews:

Address (location) of the village: ---------------------

i. Elderly Groups from the Community

1. How do you characterize the weather of this area in terms of its temperature and precipitation? Is there any change? If yes, how?

2. If you perceived the change in climate, what is your local indicator?

3. Do you farm on the same farm where your father or fort father was farming?

4. If your question to the above question is no, where is your farming land now? And why you shift to the area you are farming now?

5. Do the crops you cultivate now the same with the crops your father or fort father was growing? If no, why you change the crops?

6. Do the animals you are raring now the same as the animals your father or fort father used to rare? If no, why you change the animals?

7. Have you ever faced any climate related impact in your life time? If yes, what type of climatic shock? What did it affect? Crop/livestock

8. If the answer to Q3 is yes, what do you think the reasons of the shocks?

9. If the answer to Q3 is yes, did you adopt any strategies to minimize the risk? If yes, list.

10.What are the LMP you adopted for the above problems

11. Who do you think is most harmed by the event? Why?

12. How did the government, GOs and NGO's respond to reduce the impact?(SLMP,HZOA...)

13 What benefits do those responses by those organizations bring about?

14 is there any change from the base line situation?

14. What the government or the community should do to avert the impact of climate change in the area?

ii. Disaster Prevention and Preparedness Office (DPPO)

1. Name------------------------------------ Position---------------

2. What are the impacts of climate change on livelihood in HZW farming community?

3. What is your office role in minimizing the risks associated with climate change and variability before and after the disaster? How? have you observed any change?

4. What are your major challenges in alleviation of the problem and what should be done?

iii. Agriculture Office Officials, Development Agents ,project focal person,community facilitator and Other Experts

1. Name---------------------------------- Position-------------------

2. What is the agro-ecology of your district/kebele(s)?altitude---------- latitude-------mean annual rainfall------------- mean annual temperature--------------

3. Is there any form of Climate change in your district or Kebele(s)?

4. If your answer to question 3 is yes, would you explain the measures taken so far to minimize the risks?(eg LMP)

4. What are the benefits of those measures

5. Which group do you think is more affected? Why?

6. what differences have you observed after the mentioned measures taken and how do you evaluate it?

iv. Guiding questions used for Focus Group Discussion(FGD)

Address (location) of the village: ---------------------

Focus group size: --------------------

Focus group composition: -------------

Check list to guiding Focused group discussion

1. How do you explain climate change (Temperature, precipitation, Stream flow and vegetation cover and its type?)

2. What is the cause of climate change (Traditional how people believe the cause)

3. What are the problems related with climate change?

4. What are the impacts of climate change on agriculture and livelihood of rural people?

5. What are the adaptation strategies employed by farmers and other projects like SLMP?

6. What benefits do these strategies(LMP) have?

7. How do you identify the change from the base line situation ?

8. How do you measure these changes?

9.What are he changes on production due to LMP?

10. can you compare the income as well as production level before those LMP?

11. Which LMPs are contributing more to Climate change adaptation (production+income)