VULNERABILITY AND ADAPTATION PRACTICES TO CLIMATE CHANGE: THE CASE OF SMALLHOLDER FARMERS AT GUBA LAFTO WOREDA, AMHARA NATIONAL REGION STATE, ETHIOPIA

M.Sc. THESIS

TSEGAYE TEMESGEN

WONDO GENET COLLEGE OF FORESTRY AND NATURAL RESOURCES,

HAWASSA UNIVERSITY, ETHIOPIA

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TSEGAYE TEMESGEN

A THESIS SUBMITTED TO THE DEPARTMENT OF CLIMATE SMART AGRICULTURAL LANDSCAPE ASSESMENT, WONDO GENET COLLEGE OF FORESTRY AND NATURAL RESOURCES, SCHOOL OF GRADUATE STUDIES WONDO GENET COLLEGE OF FORESTRY AND NATURAL RESOURCES WONDO GENET, ETHIOPIA

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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Approval sheet1

This is to certify that the thesis entitled “vulnerability and adaptation practices to climate change: the case of smallholder farmers at Guba Lafto woreda, Amhara national region state, Ethiopia” is submitted in partial fulfillment of the requirement for the degree of Master of Sciences with specialization in climate smart agricultural landscape assessment. It is a record of original research carried out by Tsegaye Temesgen Id. No Msc/CSAL/R0012/09, under my 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, I recommended it to be accepted as fulfilling the thesis requirements.

_____	_____	_____
Name of major advisor	Signature	Date
_____	_____	_____
Name of Co-Supervisor	Signature	Date

Approval sheet 2

We, the undersigned, members of the Board of Examiners of the final open defense by Tsegaye Temesgen have read and evaluated his thesis entitled "vulnerability and adaptation practices to climate change: the case of smallholder farmers at Guba Lafto woreda" 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.

Name of the Chairperson	Signature	Date
Name of Major Advisor	Signature	Date
Name of Internal Examiner	Signature	Date
Name of External Examiner	Signature	Date
SGS approval	Signature	Date

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Declaration

I declare and affirm that this thesis with the title "vulnerability and adaptation practices to climate change: the case of smallholder farmers at Guba Lafto woreda" is my own work. I have followed all ethical and technical principle of scholarship in the preparation, data collection, data analysis and compilation of this thesis. Any scholarly matter that is included in the thesis has been given recognition through citation.

This thesis is submitted in partial fulfillment of the requirements for M.sc. degree in climate smart agricultural landscape assessment department at Wondo Genet College of Forestry and Natural resources. The thesis is deposited in Wondo Genet College of Forestry and Natural resources Library and is made available to borrowers under the rules of the Library. I solemnly declare that this thesis has not been submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

Tsegaye Temesgen _____ _____ June, 2018_____

Name of student Signature Date

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List of abbreviations and acronyms

AEZs	Agro Ecological Zone Systems
CRGE	Climate Resilience Green Economy
CSA	Central Statistical Agency
DFID	Department for International Development
E.C	Ethiopian Calendar
EMA	Ethiopia Mapping Agency
FAO	Food and Agricultural Organization
FDRE	Federal Democratic Republic of Ethiopia
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
HHS	Household Surveys
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
IS	Interview schedule
ITCZ	Inter-tropical Convergence Zone
MOA	Ministry of Agriculture
MoFED	Ministry of Finance and Economic Development
MRV	Measuring, Reporting and Verification
NAPA	National Adaptation Programme of Action
NGO	Non Governmental Organization
NMA	National Metrological Agency
NMSA	National Meteorological Services Agency
SCI	Save the Children International

SLF	Sustainable Livelihood Framework
SPSS	Statistical Packages for Social Sciences
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WB	World Bank

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Abstract

climate change is a real environment and development threat that need global concern. Ethiopia is dependent on rain fed agriculture, it becomes one of the most vulnerable countries to climate change. Agriculture is key livelihood in Guba Lafto woreda farmer, whose major source of livelihood is annual crops for mainly consumption and perennial crops is chiefly for market. This livelihoods are mostly suffering from drought and erratic rain fall during 'Belg' and 'Meher' seasons. However, farmers 'vulnerability and adaptation practices to climate change have not been seriously recognized nor empirically studied in Guba Lafto woreda. This study examines farmers vulnerability and adaptation practice to climate change in the context of sustainable livelihood. A questionnaire survey was conducted with a systematic random sample of 120 farmer households in three agro ecological zones namely, Laye Alawuha, Weyiney and Bekelomankiya in lowlands, midlands and highlands respectively. In addition to questioner, the study was used FGD with 30 farmers purposefully selected, IS with 15 farmers, 13 experts, 3 governmental leader, one NGO and one agricultural research institutes are deliberately selected and field observation. A modified form of sustainable livelihoods framework is deployed as analytical tool to determine vulnerability context, livelihood assets, institutions enabling or hindering adaptation and all data analyze through SPSS. The study shows climate change related problems such as drought, frequent occurrences of frost and snowfall. In addition to these climate change, socio economic related problems are farmer poor in wealth status, less land held, absences of employment opportunity and low agricultural technological capability. However, 60 (50%) of the respondents indicated on their well off (wealthy) as better well off from last 5 years ago to 2009 E.C comparison due to increasing agricultural output prices, land rent from other farmer, off farm activity employment and outside support from their relatives. Thus, the study identified the most vulnerable groups are the

poor, youth specially female and children and farmer with low agricultural technology and input capability and also their livelihoods depends only annual crop. The farmers also took a number of measures to adapt to climate change within their capacity. These adaptation practices includes changing crop variety, irrigation, crop diversification, soil and water conservation, reducing number of livestock, shifting planting date and off farm activity. The main barrier for adaptation to climate change is lack of knowledge, information, inputs, finance, labor and credits. They need government support overcome the constraints in which they face in using adaptation practices to climate change so that the sustainable livelihoods can be ensured.

key words: Climate changes, livelihood, vulnerability and adaptation practices

1. Introduction

1.1. Background

Nowadays climate change is a real environmental and developmental threat that need global concern (Abid *et al*., 2015). The harmful effects of climate induced events most negatively affected developing countries due to their social, economic and environmental conditions (Neil and Jyoti, 2007; IFAD, 2010). Climate change is projected to decrease agricultural productivity in the developing world by 10-20 % over the next 40 years (Nelson *et al*., 2009). The impacts of climate change on people's livelihoods will be high in the tropics and subtropics, particularly in Africa because many poor smallholders depend on agriculture with few alternatives (IPCC, 2001b). In Africa, negative consequences of climate change are expressed as frequent floods, droughts and shift in marginal agricultural systems (Collier *et al*., 2008).

Ethiopia is dependent on rain fed agriculture and becomes one of the most vulnerable countries to climate change (Menberu, 2016). Ethiopia's economy is highly dependent upon climate sensitive rain-fed agriculture with small proportion of cultivated irrigated land (NMA, 2007). Climate change influences Ethiopian agricultural production and has negative effect on the social and economic activities that lead to food insecurity (MoFED, 2010). According to the National Meteorological Agency, the frequency of climate change related shocks and stresses have been increasing from time to time and vary from place to place based on the adaptive capacity and resource endowment of geographical areas (NMA, 2007). The climate changes associated with rainfall variability and yield reductions are estimated to cost Ethiopia around 38 % of its potential growth rate and increase poverty by 25% (Weldegebriel and Gustavsson, 2017).

The Climate Change Vulnerability Index showed that Ethiopia is at extreme risk from the impacts of climate change (Maplecroft, 2015). In Ethiopia the major causes of under

production are change in rainfall pattern such as drought and floods, which often cause famine (Temesgen, 2007). Associated with climate change the farming community is the most vulnerable social group; even within the farming community, small-scale smallholder farmers are more vulnerable to climate change related hazards like drought (Temesgen, 2006). Ethiopia is categorized under food-insecure country since the early 1970s (Belay and Abebaw, 2004). Drought is not a new phenomenon in Ethiopia; however, the frequency of occurrence has increased in some areas and likewise the variability in rainfall patterns (Evangelista *et al*., 2013).

Climate models predict that climate change will cause decreasing rainfall in arid areas, warmer temperatures, and increasing severity and frequency of extreme weather events (Alley *et al*., 2007). Smallholder farmers are particularly unable to cope with such climate variability; they do not have the capital to invest in new adaptive practices with which to protect their homes and families. They are also especially sensitive to climatic changes since they depend almost entirely on rain-fed agriculture (Morton, 2007). The most effective way to reduce people's vulnerability to shocks and stresses is through improving their general well-being (Conway, 2009). Thus to help these smallholder farmers and to reduce their vulnerability to climate change is possible through adaptation to climate change.

Adaptation to climate change is an effective measure at the farm level, which can reduce climate vulnerability by making rural households and communities better able to prepare themselves and their farming to changes and supporting them in dealing with adverse events (IPCC, 2001). Adaptation also will require cooperation from different organization such as research and policy, those in the agricultural extension services and private welfare organizations as well as local communities and farmers (Bryan *et al*., 2013).

Guba Lafto woreda is located in Amhara region in the northern part of Ethiopia. In Guba Lafto agriculture is the main source of livelihood and income. The population living in rural areas of Guba Lafto depends on subsistence farming with less than one ha of available land for cultivation (Guba Lafto woreda agriculture office, 2016). In this area farmers are exposed to food insecurity/famines due to late onset of rain, early end of rain and droughts for agricultural practice. During 'Belg' and 'Meher' rainy seasons these rain fluctuation causes decreased water for human and livestock populations and also for crop loss with decreased livestock productivity. It also results in reduced income from agricultural production and decreased ability to meet other basic needs (North wollo agriculture department, 2016).

Most of the farmers' vulnerability and adaptation practices to climate change studies are very general and the results are organized at national levels. Thus, these all national practice may not reflect the local contexts of Guba Lafto woreda due to site-specific issues require site-specific knowledge and experience (IPCC, 2007). In addition to this, there was no other study like this research done before in the area. Thus, this study was addressed to the research questions who is/ are most vulnerable to climate change?, What are farmers' adaptation responses to climate change? And what are the constraints faced by farmers to adapt to climate change?

1.2. Statement of the problems

Climate change impact studies show that climate change will cause decreasing rainfall in arid, warmer temperature and increasing severity and frequency of extreme weather events. A recent mapping on vulnerability and poverty in Africa put Ethiopia as one of the most vulnerable countries to climate change (Yesuf *et al*., 2008). Nowadays the main problems faced in our country are climate change, food insecurity and poverty. Ethiopia is seriously threatened under climate change because of its impacts on crop, livestock, water and the

economy of the country. In general, climate change hampers the well being of the community (Weldegebriel and Gustavsson, 2017). Particularly, climate change seriously affects the people whose livelihood depends on agriculture. The poor and smallholders are the most affected as they do not have enough capacity to adapt to adverse shocks and further exacerbating the country's poverty and food insecurity situation (FAO, 2008). In association with rising temperature, people exposed to malaria and cardiovascular illnesses especially in the tropics (World Bank, 2010b).

The farmers living in the study area are mostly suffering from drought and erratic rainfall during 'Belg' and 'Meher' seasons. This phenomenon is leading to poor crop production and food insecurity. In general, it affects the welfare of the farmers. Case study shows that Ethiopian agricultural sector is negatively affected by climatic related disasters with drought and flood being the major one (Temesgen, 2007). Most of the farmers are also smallholder farmers who own small plots of land on which they grow one or two types of subsistence and cash crops depending on their family labor. It is known that smallholder farming is characterized by small farm size, low technology, and low capitalization (Seyoum, 2015). Therefore, the Ethiopian agriculture is highly vulnerable (with spatial and temporal variation) to the impact of climate change because of high exposure and sensitivity of the agriculture to climate variability and change. In addition to the impact of climate change, the vulnerability of agriculture is increased or exacerbated by the impact of other non-climatic drivers such as inappropriate land use and land degradation, population pressure, subsistence farming, low technology use and innovation and poverty (Guba Lafto woreda agriculture office, 2016). Because of these, climate change would severely affect their livelihood and agricultural productivity. Most studies indicate that poor and marginalized peoples are often most venerable to climate changes (IPCC, 2007).

In this regard, some case study findings indicated that women are more vulnerable to climate change as compared to men.

Adaptation is necessary strategy to facilitate farmers to cope with adverse effects of climate change and variability which in turn increase the agricultural production of the poor farm households (Yesuf *et al*., 2008). Also, knowledge of the adaptation methods for smallholder farmers may make them better to tackle the challenge of climate change (Temesgen *et al*., 2009).

Research findings show that vulnerability and adaptations often vary with socioeconomic, agro-ecological and cultural set up of the farmers. Different authors (e.g., Bryan *et al*. 2009; Temesgen *et al*., 2008b) have acknowledged the need of further studies of adaptation to climate change at local levels, particularly at district and villages. Therefore, in depth studies on vulnerability and adaptation should continue (Admassie *et al*., 2008). This study in this regard, contributed to bridge these gaps and attempted to reveal farmers vulnerability and adaptation practices to climate change in the context of sustainable livelihood.

1.3. Objectives

1.3.1.General objective

- To investigate farmers vulnerability and adaptation practice to climate change in the context of sustainable livelihood in Guba Lafto Woreda

1.3.2. Specific objectives

- To identify those farming households in the study area that are most vulnerable to climate changes
- To determine and describe current adaptation strategies employed at farm level in response to climate change in the study area

- To determine major constraints of agricultural adaptations to climate change in the study area

1.4. Research Questions

In order to meet the above objectives, the research questions for this study are:

- Who is/ are most vulnerable to climate change?
- What are farmers' adaptation responses to climate change?
- What are the constraints faced by farmers to adapt to climate change?

1.5. The significance of the study

The significance of this study is to reveal farmer vulnerability and adaptation to climate changes. Deep understanding of relative vulnerability of farmers within the context of climate change based on agro ecological location by identifying vulnerability groups and investigating adaptive capacity and adaptation technologies on specific area and community is important. Different authors (e.g., Bryan *et al*. 2009; Temesgenet *et al*., 2008b) have acknowledged the need of further studies of adaptation to climate change at local levels, particularly at district and villages, one of the gaps this study was aimed to fill. In such a way, the indigenous practices add knowledge to agricultural adaptation to climate change and to promote agricultural development; so that, this study will inform and provide compressive information for decision makers, experts and farmers. This study focused on site-specific issues for those require site-specific knowledge and experience (IPCC, 2007).

1.6. The scope and limitations of the study

The scope of this study was focused on geographical location, livelihood system, and response measures to climate change. With regard to geographical location, Ethiopia is affected by climate change due to its low level of economic development, heavy dependence on rain fed agriculture and high population growth (Eshetu *et al*., 2014). In the

study area the farmers are exposed to food insecurity/famines due to late rain, early rain out and droughts for agricultural practice. During 'Belg' and 'Meher' rainy seasons this rain fall fluctuations cause a decreased water for human and livestock populations and also for crop loss with decreased livestock productivity that result in reduced income from agricultural production and decreased ability to meet other basic needs (North wollo agriculture department, 2016). There were no studies on climate change in this woreda so that, this research has coverage of geographical location in Amhara region.

With regard to livelihood system the study will focus on one woreda at three agro ecological locations i.e. lowlands 'Kola', midlands 'Weynadega' and highlands 'Dega' kebeles to analyze livelihood and adaptation practices in these three agro-ecological zones. The case of rain fed agricultural livelihoods of Ethiopia is limited (Temesgen *et al*., 2010). The farmers livelihood in this study area mainly depends on agriculture. The farmers have been exposed to vulnerability. Therefore, these farmers need special attention.

In terms of response measures to climate change, the scope of this study was focused on adaptation rather than mitigation of climate change because, to reduce greenhouse gases it will take time, requires international cooperation and its scale of effect is at the global level (Fussel and Klein, 2005). The second reason is benefits of adaptation is incremental income through sustainable intensification or diversification, poverty reduction and the growth of the economy, functioning environmental services and reduced carbon emissions (IFAD, 2013). The third reason is Ethiopia's National Meteorological Agency produced a National Adaptation Programme of Action (NAPA) in 2007 with the aim of identifying priority activities that respond to urgent and immediate needs for adaptation to climate change. Because of these reasons the study was focused on adaptation rather than mitigation of climate change.

The major limitation of this study was taken one woreda in eastern part of Amhara region with 120 sample households from three Kebeles of Guba Lafto woreda due to limited financial resource and time. Even if climate change and its effect is a complex phenomenon, the study is focused on the socio-economic, demographic, livelihood system and asset aspects of households that often show heterogeneity within a community and also affect the vulnerability of smallholder farmers and their adaptation measures to climate change with limited dimensions of climate change issues.

1.7. Organization of the thesis

The thesis is organized with introduction that details the background and introductory part of the study then the second part review of related literature followed. The third part is devoted to materials and methods. The fourth part constitutes result and discussion about venerability and adaptations practices to climate change in the context of sustainable livelihood in Guba Lafto woreda. The fifth part is conclusion and recommendation.

2. Literature Review

2.1. Effect of climate change on social, economic and environmental condition

Climate change is any change in climate over time, whether because of natural variable or as a result of human activity (IPCC, 2007b). In the context of Ethiopia, Ethiopian National Adaptation Programme of Action defined climate change; it is a change in precipitation patterns, rainfall variability and temperature which could increase the frequency and occurrence of floods and droughts (NAPA, 2007). Climate change is differ from climate variability in that climate variability is cyclical up and downs over short time scale. Nowadays climate changes is real and occurs in every coroners of the globe. Research findings show that greenhouse gases (GHGs) concentration in the atmosphere at global level has been rising due to as a result of human activities. This accumulation of greenhouse gases in the atmosphere is expected to alter the atmospheric balance and enhance the natural greenhouse effect and leading to a change in climate variables such as temperature, precipitation and solar radiation. Changes in climatic variables intensify climate extremes. For example, drought and floods occur naturally around the globe. On scientific basis two factors are raising the temperature of the atmosphere: One is chemical reaction inside the earth system which does not result in any significant change and the second one is the interaction between solar radiation and greenhouse gases which create significant change in temperature. Throughout the 20th century, Earth's mean worldwide temperature rose by almost 0.74 ℃ and is projected to increase by 1.1 ℃ to 6.4 ℃ by the end of the 21st century (IPCC, 2007a). In Ethiopia the total emission around ~150 Mt CO2e represent less than 0.3% of the global emissions and the majority of emissions are from agriculture sector that comes from livestock, crops and deforestation (FDRE, 2011). The average annual temperature in Ethiopia is projected to increase by 1.1°C to 3.1°C by

the 2060s (UNDP, 2012). Different scientific research at global level reveals that climate change impact and brings about environmental, social and economic consequences.

Social impact of climate change is human health related diseases and injuries are introduced especially in hot areas, and become highly prone to disease outbreak. Ethiopia is already affected by higher average temperatures and changing rainfall patterns, and persistent drought has exacerbated food insecurity and the need for international food aid (Miles, 2014). Changes in temperature will have direct and indirect impacts on livestock production and the pastoralist communities that depend on them were be affected (Abebe, 2012). For example, in Guba Lafto woreda drought occurs frequently and farmers are victim to famine because their livelihood mainly rely on rain fed agriculture. Therefore, this woreda is under safety net program to support subsistence farmers and to protect chronically food insecure, individuals' assets and livelihoods.

Environmental impact of change associated with water resources, some areas receives high amount of rainfall while some areas receive very little or no rain. Because of too much water in some area different problems like landslides, floods etc may occur, whereas with too little water the drought problem occurs in other parts. The drought and erratic rainfall events have been observed in more intense form with longer duration, and this makes the water availability scarce or by making muddy it becomes unsafe for drinking. The forests and biodiversity are also affected by climate change, 2.4 % of the biodiversity is in danger of extinction due to climate change. Increasing temperature is reducing the soil moisture and keeping air dry because of which forests become prone to fires. Floods, landslides, soil erosion also trigger the forest destruction (Amita *et al.*, 2011). All the consequences of climate change, i.e.; temperature rise, variation in rainfall, sea level rise and increasing intensity and frequency of extreme climatic events will adversely affect the environment

and also floods and drought reduces the fertility of the soil result in agricultural yield decreases.

Economic impact of climate change aspect, climate models show that climate change will lead to warmer temperatures, increasing rainfall variability and increasing severity and frequency of extreme weather events. These changes are expected to decrease agricultural productivity in the developing countries by 10 % to 20 % over the next 40 years (Nelson *et al*., 2009). The average annual temperature in Ethiopia increased by $1.3^{O}C$ between 1960 and 2006 (UNDP, 2010). In the context of Ethiopian agriculture, agriculture plays a central role in the economic and social life of the people of Ethiopia. It contributes about 40-50 percent of gross domestic product (GDP), and generates more than 90 percent of foreign exchange earnings and employ 80-85 percent of the population (Negra, 2014). The climate changes associated with rainfall variability and yield reductions are estimated to cost Ethiopia around 38 % of its potential growth rate and increases poverty by 25 % (Weldegebriel and Gustavsson, 2017). Also climate changes introduce new variety of pests and diseases that hamper the crops. It is particularly difficult for subsistence farmers to cope up with climate related hazards due to lack of capital to invest in new adaptive practices to protect their homes and families. Especially among households that sensitive to climatic changes are those households that depend on rain-fed agriculture for their livelihoods (Thorlakson and Neufeldt, 2012).

2.2. Vulnerability to climate change

Vulnerability can have a number of definitions based on different disciplines with many conceptual approaches to use in vulnerability studies and analysis (Temesgen *et al*., 2008). Therefore, it is generally accepted that a single definition of vulnerability satisfying all assessment contexts does not exist (Fussel, 2007). According to IPCC in relation to climate change, vulnerability refers to the degree to which a system is susceptible to, or unable to

cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2001). This explanation includes an external dimension (exposure) and internal dimension (sensitivity and adaptive capacity) to these stressors.

The Climate Change Vulnerability Index reflects the vulnerability of different countries to extreme climate related events and changes in major climate parameters. It showed that, Ethiopia is at extreme risk from the impacts of climate change (Maplecroft, 2015).

Vulnerability is a key issue to study in the context of climate change at different level for Ethiopian farmers because vulnerability takes into account individual characteristics, farm size, resource distribution, scope of production (food staples and cash crops) and livestock and off farm activities (Cooperative and Enterprise Development Directorate, 2012).

The basic characteristics of vulnerability is multi-dimensional (e.g. physical, social, economic, environmental, institutional and human factors define vulnerability); dynamic i.e. vulnerability changes over time; scale-dependent (vulnerability can be expressed at different scales from human to household to community to country resolution) and site-specific. Thus Vulnerability is a characteristic, threat, or condition; not readily measured or observable, thus we need proxy measures and indicators. Different authors have argued that vulnerability is a relative measure rather than something that can be expressed in absolute terms (e.g., Downing *et al*., 2001).

2.2.1. Conceptual approaches to vulnerability

There are many conceptual methodological approaches to vulnerability analysis. Three major conceptual approaches to analyze vulnerability to climate change are: the socioeconomic, the biophysical (impact assessment) and the integrated assessment approaches.

2.2.1.1. Socioeconomic approaches

It regards vulnerability as an a prior form of a household or a community that is conditional on socio-economic and political factors (Fussel, 2007). The socioeconomic factors include the level of technological development, infrastructure, institutions, and political setups (McCarthy *et al*., 2001). Individuals in a community often differ in terms of education, gender, wealth, health status, access to credit, access to information and technology, formal and informal (social) capital, political power and so on. These variations are accountable for the variations in vulnerability levels. In this case, vulnerability is measured to be a starting point or a state (i.e., a variable describing the internal state of a system) that exists within a system before it encounters a hazard event (Allen, 2003; Kelly and Adger, 2000). Overall, the socioeconomic approach focuses on identifying the adaptive capacity of individuals or communities based on their internal characteristics. Some of the internal characteristics are poverty in inequality, health, and access to resources such as food entitlements, access to insurance, and housing quality, and social status (Adger and Kelly, 1999). The main limitation of socioeconomic approach is focused only on variations within society but in reality, societies vary not only due to sociopolitical factors but also to environmental factors (Temesgen *et al*., 2008). Despite its weaknesses, however, this research is followed socioeconomic approach because socio economic variation exposed people to vulnerability in a way exacerbated by climate change.

2.2.1.2. Biophysical approach / Risk – hazard framework/ Impact assessment

This approach assesses the level of harm that a given environmental stress causes on both social and biological systems. The biophysical approach is mainly worried with the physical impact of climate change on different attributes, such as yield and income (Fussel and Klein, 2006). According to this explanation vulnerability corresponds most closely to

'sensitivity' in IPCC terminology. The impact assessment approach as an end-point analysis responding to research questions such as, "What is the extent of the climate change problem?" and "Do the costs of climate change exceed the costs of greenhouse gas mitigation? (Kelly and Adger, 2000). The Limitations of biophysical approach is focusing mainly on physical damages, such as yield, income, and so on, but they do not show what that particular reduction means for different people (Temesgen *et al*., 2008).In general, the biophysical approach focuses on sensitivity (change in yield, income, health) to climate change and misses much of the adaptive capacity of individuals or social groups, which is more explained by their inherent or internal characteristics (Adger, 1999).

2.2.1.3. Integrated assessment approach

The integrated assessment approach embrace both socioeconomic and biophysical attributes in vulnerability analysis (Fussel, 2007). The IPCC definition which conceptualizes vulnerability to climate as a function of adaptive capacity, sensitivity, and exposure accommodates the integrated approach to vulnerability analysis (Fussel, 2007; Fussel and Klein, 2006). This approach acknowledges that vulnerability to climate change is multidimensional and a function of biophysical outcomes related to variations and changes in temperature, precipitation, topography, and soils as well as sociopolitical, institutional factors depending on a country's level of economic development (Agrawal, 2010; Adger, 2006). One of the limitations of the integrated assessment approach is, the lack of standard method for combining the biophysical and socioeconomic indicators. This approach uses different data sets, ranging from socioeconomic data sets to biophysical factors; and these data sets certainly have different yet unknown weights. This analysis provides no common metric for determining the relative importance of the social and biophysical vulnerability, nor for determining the relative importance of each individual

variable. Therefore, much care is required (Cutter *et al*., 2000) and also it does not account for the dynamism in vulnerability (Temesgen *et al*., 2008).

2.2.2. Vulnerability of agricultural communities to climate change

Community vulnerability depends on the degree of climate change a system, community, household or individual is subjected to subsequent climate variable (exposure), the impact climate changes have on the entity (sensitivity) and the ability of the system or community to adjust to the changes (adaptive capacity) (Satapathy *et al*., 2011). Vulnerability to climate change can vary based on where people live, how they gain their livelihoods, how poor they are, how much power they have and gender.

In Ethiopia, the most vulnerable groups are people marginalized due to their economic status, ethnicity, sex, age, and education through a stakeholder analysis of vulnerability to climate change. Associated with climate change the farming community is the most vulnerable social group; even within the farming community, small-scale smallholder farmers are more vulnerable to climate change related hazards like drought (Temesgen, 2006). Case studies indicate, most developing countries are particularly vulnerable due to their social, economic and environmental conditions that easily susceptible to negative impacts and have low capacity to cope with and adapt to climate hazards (Neil and Jyoti, 2007). Other Case studies, show that Ethiopian agriculture is highly vulnerable (with large spatial and temporal variation) to the impacts of climate change because of high exposure and sensitivity of the sector to climate variability and change (Weldegebriel and Gustavsson, 2017).

2.3. Adaptation to climate change

Adaptation to climate change is an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Adaptation can be distinguished as anticipatory, autonomous and

planned adaptation (IPPC, 2007e). Anticipatory are responses taken in advance of climate changes also referred as proactive adaptation. Autonomous is adjustments made within the system also referred as spontaneous adaptation. Planned adaptation means adjustments made outside the system, such as those initiated or prompted by public policy. Most adaptation strategies in developing countries like Ethiopia in any sectors are reactive type (an adaptation that takes place in response to already observed climate stimuli) with both private and collective forms (Weldegebriel and Gustavsson, 2017).

Adaptation under United Nations Framework Convention on Climate Change /UNFCCC/, UNFCCC is agreed in 1992 and it is the main international treaty on combating climate change. Its objective is to prevent dangerous man-made interference with the global climate system. The members are dedicated to launch national strategies for adapting to estimate impacts including the provision of financial and technological support to developing countries and to assist in preparing for adaptation to the impacts of climate change. The Conference of the Parties to the UNFCCC has made several decisions in regard to adaptation to climate change. The Convention's Subsidiary Body for Implementation addresses agenda items on vulnerability and adaptation in the context of climate change negotiations. Particular attention has so far been given to issues relating to Article 4.8 and 4.9.

Thus adaptation in agriculture is to diminish farmers' vulnerability and improve their adaptive capacity. Research findings showed that benefits of adaptation is incremental income through sustainable intensification or diversification, poverty reduction and the growth of the economy, functioning environmental services and reduced carbon emissions (IFAD, 2013).

According to IPPC, adaptive capacity in relation to climate change impacts is not only the ability of a system to adjust to climate change including climate variability and extremes to

moderate potential damages, to take advantage of opportunities, or to cope with the consequences but also the whole of capabilities, resources and institutions of a country or region to implement effective adaptation measures (IPPC, 2007e).

Ethiopia has its Climate Resilient Green Economy (CRGE) strategy focus on mitigation strategies in Ethiopia. However, adaptation is more of complex due to its is a function of economy, politics, culture, etc. It should be given prior emphasis in the county as compared to mitigation strategies. Thus, anticipatory and planned adaptation is an immediate concern. However, vulnerabilities are mostly local and adaptation should be highly location specific. Most adaptation efforts are realized at the local level, hence their effectiveness depends on local institutions through which incentives for individual and collective actions are structured (Agrawal, 2010). Also in adaptation strategies risk transfer mechanisms should have to be included from the national to the household level.

Thus adaptation strategies should be strengthening resilience to current variability and future climate change. Resilience is the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization and the capacity to adapt to stress and change (IPPC, 2007). Resilience and adaptive capacity intimately associated concepts. Resilience is about bouncing back, ideally in a way that enhances the ability to manage future hazards. Adaptive capacity is about managing uncertain and dynamic changes in a way that allows improvement in well-being over time. Thus based on all the above facts adaptation is a necessary strategy at all scales to complement climate change due to the effect of emission reductions (mitigation) takes several decades to fully manifest, whereas most adaptation measures have more immediate benefits; adaptations can be effectively implemented on a local or regional scale, whereas mitigation of climate change requires international cooperation, such that their efficacy is less dependent on the actions of others and most

adaptations to climate change also reduce the risks associated with current climate variability, which is a significant hazard in many world regions.

2.4. Impact of climate change on agricultural communities

IPPC in its fourth assessment report clearly put the extent of the effect of climate change and variability on African agriculture as follows: "Agricultural production, including access to food, in many African countries and regions is projected to be severely compromised by climate variability and change. The area suitable for agriculture, the length of growing seasons and yield potentials, particularly along the margins of semi-arid and arid areas, are expected to decrease. This would farther adversely affect food security and exacerbate malnutrition in the content. In some countries, yield from rain-fed agriculture could be reduced by up to 50 % by 2020." (IPPC, 2007).

Ethiopia is one of the biggest food aid receipt countries in Africa that accounts to 20-30 % of all food aid to sub- Saharan Africa (Bezu and Holden, 2008). This is due to the fact that agricultural production in Ethiopia is adversely affected by climate change which is decreasing crop yield, decrease in livestock feed availability, affecting animal health and expansion of desertification. In addition to these the main environmental problem in Ethiopia is the recurrent droughts due to its agriculture mainly depends on rainfall, thus drought highly affects agricultural production and the livelihood of the farming population also result in starvation, death and foreign aid dependence (Temesgen *et al*., 2010).

2.5. Adaptation of agricultural communities to climate change

In the previous sections (2.3) I have described the theoretical foundation of adaptation. In this section I will focus on adaptation practices implemented by smallholder farmer. Adaptation of the agricultural sector is crucial to protect the livelihoods of the poor and to ensure food security (Elizabeth *et al*., 2009). Adaptation can seriously diminish vulnerability to climate change by building rural communities better able to adjust to

climate change and variability, moderating potential damages and helping them cope with adverse consequences (IPCC, 2001).

Historically, people whose livelihoods rely on agriculture have developed habits to cope with climate variability autonomously. Today, the current speed of climate change will adjust known variability patterns to the extent that people will be confronted with situations they are not equipped to handle (FAO, 2008)

In Ethiopia agricultural adaptation to climate change is not new. At the micro level (farm level) adaptations are like changing planting dates, planting trees, adoption of drought tolerant and early maturing crops/varieties, increased use of soil and water conservation techniques and/or soil erosion prevention programs, diversification into non-farming activities, increased use of irrigation and/or use of irrigation techniques, the herd composition, applying different feed techniques, temporary or permanent migration, home-garden agriculture, and drawing down on livestock or savings (Weldegebriel and Gustavsson, 2017). Other finding show that in response to the recurrent droughts and related environmental damage, farmers in Ethiopia have developed different coping strategies such as sale of animals, loan from relatives, sale of crop outputs and own cash (MoFED, 2007). However, some case studies indicated that lack of information, lack of money, shortage of labor, shortage of land and poor potential for irrigation as barriers to adaptation in Ethiopia (Temesgen *et al*., 2009).

2.6. Agro ecological Features of Ethiopia

The climate of Ethiopia is mainly controlled by the seasonal migration of the Inter tropical Convergence Zone (ITCZ), which follows the position of the sun relative to Earth and the associated atmospheric circulation, in conjunction with the country's complex topography (NMSA, 2001). The most commonly used classification systems are the traditional and the agro ecological zone systems (AEZs). According to the traditional classification system,

which mainly depend on altitude and temperature, Ethiopia has five climatic zones (MOA, 2000).

Table 1. Traditional climatic zones and their physical characteristics

Zone	Altitude (m)	Rainfall (mm/yr)	Average annual temperature (°C)
Wurch (upper highlands)	> 3,200	900–2200	> 11.5
Dega (highlands)	2,300–3,200	900–1,200	17.5/16.0–11.5
Weynadega (midlands)	1,500–2,300	800–1,200	20.0–17.5/16.0
Kola (lowlands)	500–1,500	200–800	27.5–20.0
Berha (desert)	< 500	< 200	> 27.5

Source: MOA, 2000

2.7. Livelihood framework as analytical tool

Livelihood defined as a combination of the resources used and the activities undertaken in order to live. The resources might consist of individual skills and abilities (human capital), land, savings and equipment (natural, financial and physical capital, respectively) and formal support groups or informal networks that assist in the activities being undertaken social capital (DFID, 2001).

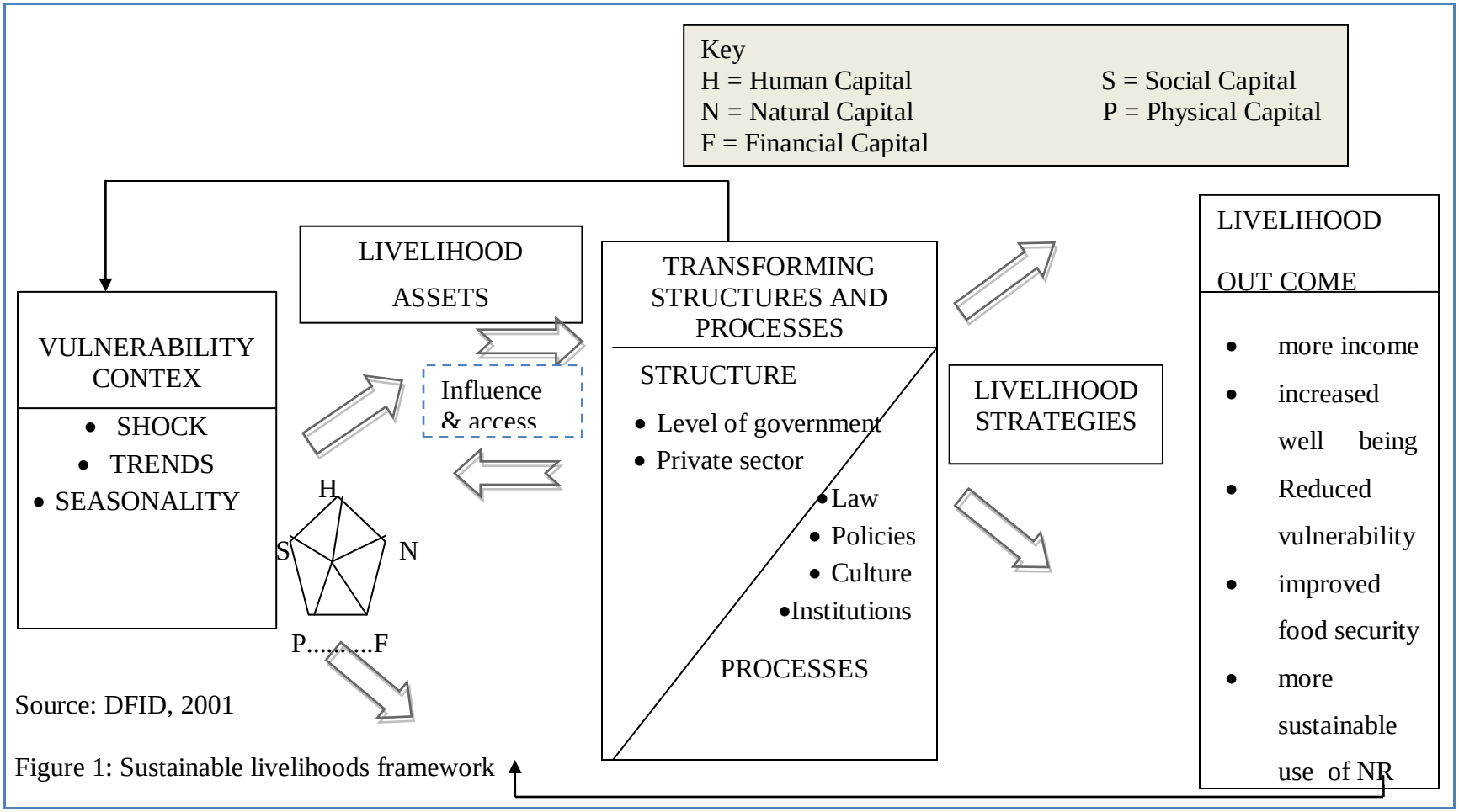
Sustainable livelihood pertains to livelihood that can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, without undermining the natural resource base (Ibid).

The livelihoods framework is a way of understanding how households derive their livelihoods by drawing on capabilities and assets to develop livelihood strategies composed of a range of activities. The livelihoods framework helps us to identify (and value) what people are already doing to cope with risk and uncertainty, make the connections between

factors that constrain or enhance their livelihoods and identify measures that can strengthen assets, enhance capabilities and reduce vulnerability.

The sustainable livelihood framework (SLF) presenting the main factors that affect people's livelihoods and relationships between vulnerability context, livelihood assets, structures and processes, strategies and outcomes (Ibid).

The SLF approach is usually used to design development programmes at the community level, and is very useful for assessing the ability of households to withstand shocks. However, there are a number of general criticisms. This criticisms such as its inability to capture the dynamism in capital assets over time, the high levels of resourcing and skills required to implement the framework on the ground and insufficient attention to the often complex ecological consequences of livelihood adaptations (small, 2007). However, these research would be followed DFID Sustainable Livelihood Framework (SLF) as analytical tool.



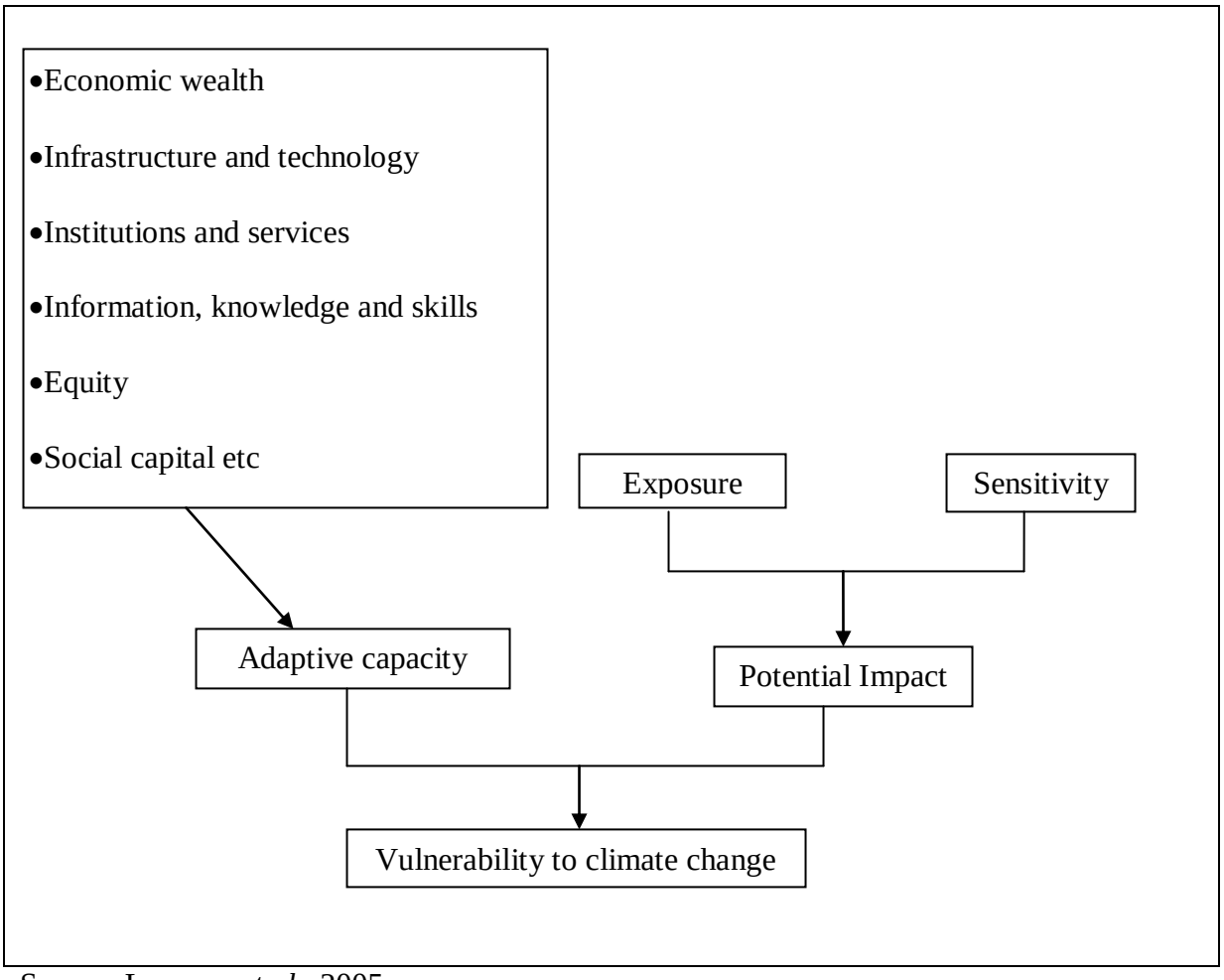
Source: DFID, 2001

Figure 1: Sustainable livelihoods framework

2.8. Conceptual framework of the study

The IPCC's (2001) definition of vulnerability was adopted for this study by adapting it to the Ethiopian context. The IPCC defines vulnerability to climate change as follows:

The degree to which a system is susceptible, or unable to cope with adverse effects of climate change, including climate variability and extremes, and vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity. Figure 2 shows the conceptual framework of vulnerability for this study.



Source: Lonescu *et al*., 2005

Figure 2: conceptual framework of vulnerability for this study

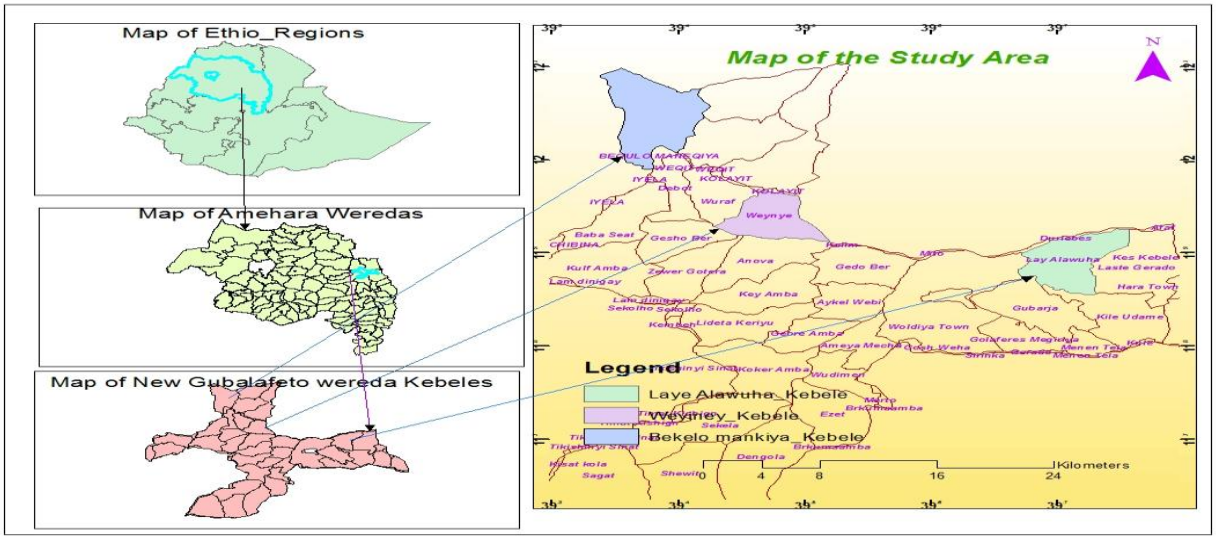
3. Material and methods

3.1 Site Description

3.1.1 Geographical Location

The study was carried out in Guba Lafto woreda North Wollo Zone, located at latitude 12^0 $00^{'}$ $0.00^{"}$ N and longitude 39^0 $19^{'}$ $60.00^{"}$ E at a distance of approximately 520 km from Addis Ababa and 360 km from the regional town Bahir Dar (Guba Lafto woreda agriculture office, 2016). Guba Lafto woreda is bordered with South wollo zone and Habru woreda in the south, Gidan Woreda in the north, Delanta,Wadla and Meket woredas in the west and Kobo woreda in the east. It has 34 rural Kebles (Kebele is the lowest administrative units of Ethiopia).

The households' survey was carried out in Guba Lafto woreda within three traditional agro ecological zones according to their altitude. Namely, Bekelomankiya kebele located in 'Dega' (highlands) agro ecological zone, Laye Alawuha in 'kola' (lowlands) and Weyiney kebeles located in 'Weynadega' (midlands) agro ecological zones.



Source: EMA/Ethiopia Mapping Agency/ Wereda and Kebele Shape file

Figure 3: Map of study sites

3.1.2. Climate

Based on agro-ecological classification 37% of the Woreda is highlands (Dega), 46% is mid-highlands (weynadega) and 17% lowlands (kola). The mean annual rain fall of the woreda is 500-700 mm per year. Rain fall is bimodal, i.e. the main rain fall season (Meher) from June to August and short rain fall season (Belg) occurs in February/March. From the 34 rural kebeles eight kebeles are exclusively Meher dependant (24%), 12 kebeles are exclusively Belg dependent (35%) and 14 kebeles (41%) can be used to harvest in both seasons. The rain fall is erratic and high intensity for short period of time. The months of April and May are the hottest/warmest months whereas low temperature occurs during October to January (Guba Lafto woreda office of agriculture, 2016).

3.1.3. Soils

The soil of Guba Lafto woreda is mostly covered by lithosols. Other soils are vertisols, cambisols and regosols. The property of the soil is acidic in nature due to heavy soil erosion (Ibid).

3.1.4. Population

The human Population in Guba Lafto woreda is 168,406 people, from these 86775 (52%) are male and the rest 81631(48%) are female. The average family size is five people per household. The majority of populations are active labor age. The population size of Bekelomankiya kebele alone counts 662, of which 430 are male and 232 are female. On the other hand, Laye Alawuha kebele, has a total population of 1038 of which 761 are male and 277 are female likewise Weyiney kebele has1325 people, from these 994 are male and 331 are females (Ibid).

3.1.5. Area Coverage and Land use

Guba Lafto woreda covers a total land area of around 103440 hectares from this 36113.8 ha is agricultural land, 16879.6 ha forest land, 10817.03 ha grass land and the other land use such as 3143.9 ha is wood land. Each land use based on type and ownership has been registered and certified by the Woreda environment, land administration and use office (Ibid).

Bekelomankiya kebele has a total land area of 4127 ha. Out of this total land, cultivable land covers 1279 ha, grazing land 1053 ha, forest and shrub cover 1002 ha, building covers793 ha whereas Laye Alawuha and Weyiney kebeles cover a total land area of 4155 ha and 1286.66 ha respectively. Out of this total land, cultivable land covers 1370 ha, grazing land 130.11 ha, forest and shrub cover 180.1 ha, building covers 231.7 ha and degraded land 486.3 ha in Laye Alawuha and Weyiney kebele has cultivate land covers 487 ha, grazing land 61.5 ha, forest and shrub cover 275 ha, building covers 358 ha (Ibid).

3.1.6. Vegetation

The main woody vegetation found in Guba Lafto woreda are *Eucalyptus camaldules* and *Eucalyptus globullus* (dominant), C*upressus lustanica*, O*leaa fricana*, different types of *Acacia species* and *Hagenia abyssinica* and *Junipers procera* with small coverage (Ibid).

3.2. Methods

3.2.1 Site Selection and Sampling Procedures

Based on traditional and the agro ecological zone systems (AEZs), three climatic zones were selected derived on sample drawn through simple random sampling using lottery method to determine vulnerability of farmers household to climate change in the context of sustainable livelihood and to identify adaptation practices and its constraints.

Lists of participants for the household survey was obtained from total lists of each kebele residents in the hand of kebele administrators and samples were drawn from the list through systematic random sampling techniques. A total of 120 households heads were selected by Yemane formula (1967) as cited in Israel (1992). Out of 120 households for Bekelomankia, Laye Alawuha and Weyiney kebeles 26, 41 and 53 households respectively were selected by Yemane method (1967) as cited in Israel (1992) to represent equal chance of households in each kebele.

Thirty (30) farmers were selected from three kebeles for Focus group discussion (FGD). The selection of participant for this purpose was done by brief meeting and the ten (10) farmers from each of the three kebeles different 'gots' were purposefully selected, consisting of two elders, two middle aged persons, two young persons and four women of different age groups..

While 15 farmers, 13 experts, 3 governmental leaders at kebele level, one SCI nongovernmental organization and one Sirinka agricultural research institutes were also selected for interviews. The selection of participants for was based on purposive sampling considering their knowledge about the area, age and gender.

Moreover, the survey questions were initially drafted in English and later translated into Amharic language. Training was given for data enumerators while pre-testing was also done by distributing questionnaires to ten farmers in the site who was not involved in the actual survey and excluded during the data analysis.

3.2.2. Data source and type

Quantitative and Qualitative data were gathered from primary and secondary sources. Household survey was applied to assess and find out household characteristics, demographic and social characteristics, livelihood system and assets, vulnerability to climatic risk, Agricultural production and production input and adaptation strategies. Qualitative data help to better

understand the impact, vulnerability and also to identify vulnerable group and adaptations to climate change in the study area.

3.2.3. Method of data collections

For this research interview schedule (IS), Focus group discussion (FGD), household surveys (HHS) and direct observation were used as a data collection instruments. In FGD help to better understand the impact, vulnerability and also to identify vulnerable group and adaptations and their constraints in the study area. Open ended checklists were designed to administer the Interview schedule (IS) and Focus group discussion (FGD). Likewise, closed and open-ended questionnaires developed to administer the household survey (HHS). Direct observation assisted to understand and obtain information for the study.

3.2.4. Data Analysis

The data was analyzed with descriptive statistics (frequency, Explore and cross tabs) using Statistical Packages for Social Sciences (SPSS) version 16. In addition to this sustainable livelihood framework was used as analytical tool to livelihood.

4. Result and Discussion

4.1. Result

4.1.1. Socio economic profile of sampled households

The study samples were included both male 90.8 % (109) and female 9.2 % (11) headed households. The majorities 86.7 % (104) of the households were married (Table 2).

The family size of the sampled households vary from small to large group with the average family size of 4.64 (S.D=1.913), slightly below the national average 5.1 family size (CSA and WB, 2013). The minimum and maximum family size in the study area were one and 14 members respectively.

Households living in the study area are 557 (282 male and 275 female). Of these (52.78 %) 294 peoples (155 male and 139 female) have little labor contribution to production and income generation activities of the household.

Survey results in the study area revealed that 85 % (102) of the respondents engage in farming only whereas 15 % (18) engaged in farming and off farm activities. Farmers in the Weyiney seem to be engaged in farming and off farm activities than farmers in the Bekilomanekia and Laye Alawuha (Table 2)

Of the total respondents in the study area most 59.2 % (71) were categorized under poor, 35.8 % (43) medium and only 5 % (6) respondents were rich (Table 2) with an average monthly income of 1262.70 Ethiopian birr per household's.

This finding also considered the type of houses in which the farmers live in. The majority 81.7 % (98) households live in iron roof houses and 18.3 % (22) living in a traditional thatch grass roof houses.

Regarding to farmers' education, 80.8 % (97) farmers in the study area can read and write (literate) whereas the rest 19.2 % (23) can't read and write (illiterate).

Most respondents 90.8 % (109) and 99.2% (119) were Orthodox in religion and Amhara in their ethnicity respectively, which reflect the populations in the study area are almost homogenous in religion and ethnic background (Table 2).

Table 2: Socio economic profile of sampled households

Variable	Frequency (%)	Survey sites		
		Laye alawuha	Woyeneye	Beklomaneqeya
Sex				
Male	109(90.80)	35(85.40)	49(92.50)	25(96.20)
Female	11(9.20)	6(14.60)	4(7.50)	1(3.80)
Marital status				
Married	104(86.70)	32(78.00)	48(90.60)	24(92.30)
Single	8(6.70)	3 (7.30)	4(7.50)	1(3.80)
Divorced	6(5.00)	4 (9.80)	1(1.90)	1(3.80)
Widow	2(1.70)	2 (4.90)	0(0.00)	0(0.00)
Family size (group)				
Small (1-5)	86(71.70)	35(85.40)	37(69.80)	14(53.80)
Medium (6-8)	31(25.80)	6(14.60)	14(26.40)	11(42.30)
large (8-10)	1(8.00)	0(0.00)	1(1.90)	0(0.00)
very large (11-15)	2(1.70)	0(0.00)	1(1.90)	1(3.80)
Total people live in the area	557(100)	148(26.57)	270(48.48)	139(24.95)
Labor dependent people	294(100)	70(23.81)	149(50.68)	75 (25.51)

Continue

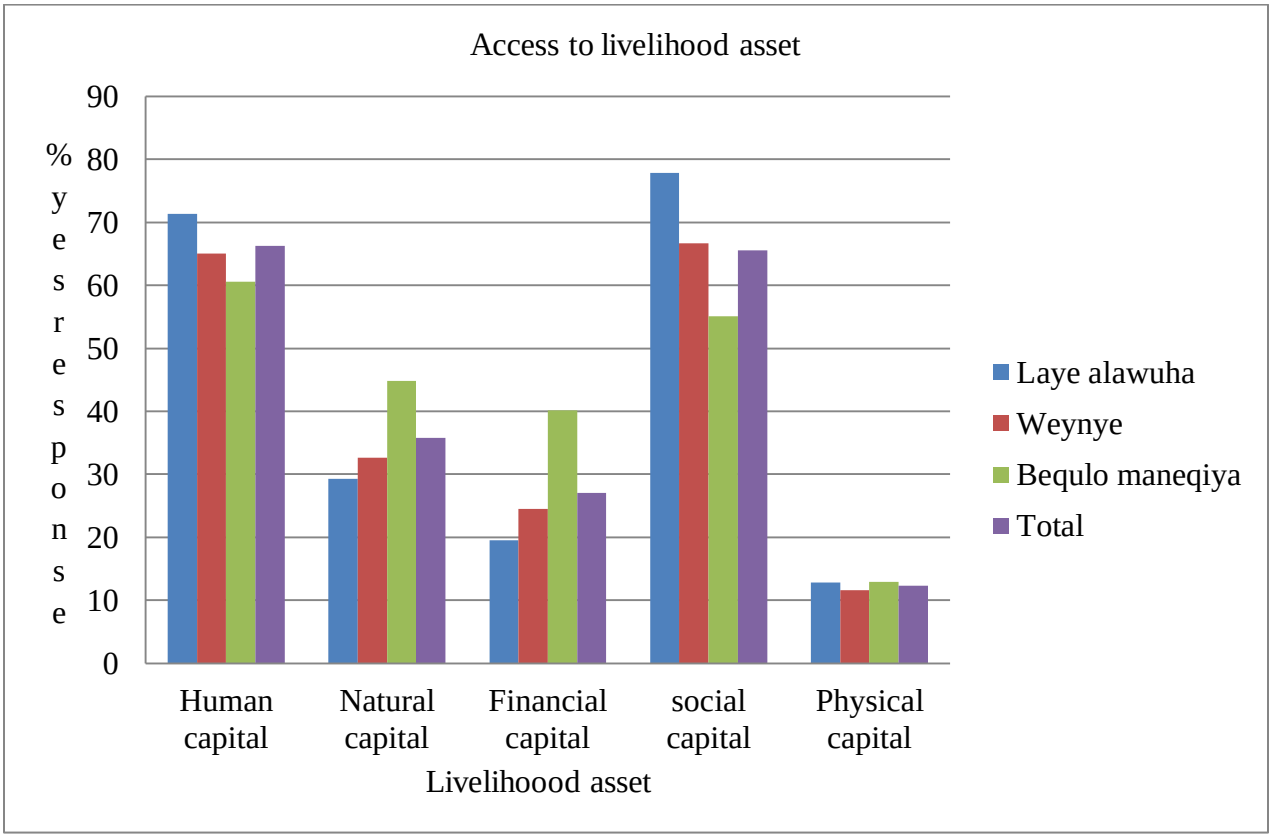
Variable	Frequency (%)	Survey sites		
		Laye alawuha	Woyeneye	Beklomaneqeya
Major occupation				
Farmer	102(85)	38(92.68)	43(81.13)	23(88.46)
Farmer and off farm activity	18(15)	3(12.20)	10(18.90)	3(11.5)
wealth status				
Poor	71(59.17)	26(63.41)	27(50.94)	18(69.23)
Medium	43(35.83)	14 (34.15)	25(47.17)	4(15.38)
Rich	6(5.00)	1(2.44)	1(1.89)	4(15.38)
Education				
Literate	97(80.80)	38 (92.70)	42(79.20)	17(65.40)
Illiterate	23(19.20)	3(7.30)	11(20.80)	9(34.60)
Religion				
Orthodox	109(90.80)	33(80.50)	50(94.30)	26(100)
Muslim	10(8.30)	7(17.10)	3(5.70)	0(0)
Protestant	1(0.80)	1(2.40)	0(0.00)	0(0.00)
Ethnicity				
Amahara	119(99.20)	41(100)	53(100)	25(96.20)
Other	1(0.80)	0(0.00)	0(0.00)	1(3.80)

Source: survey data, February 2018

4.1.2. Livelihood assets and options

4.1.2.1. Livelihood assets

In line with access to livelihood assets, respondents rating of access to human and social capital in all AEZs are 66.25 % and 65.53 % respectively while the corresponding figure of access to natural and financial capital are 35.83 % and 27.00 % respectively. Overall, access to physical capital scores were the least i.e. only 12.32 % (Figure 4).



Source: survey data, February 2018

Figure 4: Access to livelihood assets

Contingency table test of household livelihood asset in all zones shows that households are differently endowed with assets. Chi square test table are calculated to show the significance of association between livelihood assets and AEZs. Components of human capital show significant association in food production and income (Pearson Chi square values, degrees of freedom and

probability are 11.236, 2 and 0.004 respectively at 0.01 level of significance) between agro ecological areas and household's over the last 12 months. However, the same is not true the case with the components of health facility, schools of education and agricultural training.

In terms of inter-site comparison, Laye Alawuha scored higher on household's food production and income over the last 12 months have been sufficient to cover what they consider to be the needs of the household than Weyiney and Bekelomankiya.

As the result showed from the table 3, the components of natural capital indicated significant dependent or association between agro ecological and household's free grazing land access to ownership with Pearson chi square values, degrees of freedom and probability are 18.805, 2 and 0.001 respectively at 0.01 level of significance. In addition to household's access to free grazing land, significant relationship between agro ecological and Private plantation of perennial crop access to ownership with Pearson chi square values, degrees of freedom and probability are 18.528, 2 and 0.001 respectively at 0.01 level of significance.

Inter site comparison, natural capital scored low in all sites to access of ownership for community grazing land reported below 35% (Figu.4). More people reported having or using free grazing land in Laye Alawuha than the other two sites. Ownership access to natural capital is lower in Bekelomankiya due to shortage of land size.

Among the components of financial capital, Credit(formal and informal) shows significance of association across agro ecological sites with Pearson chi square values, degrees of freedom and probability are 27.431, 2 and 0.001 respectively at 0.01 level of significance. Bekelomankiya scored high for Credit. Access to credit is low in Laye Alawuha around 15 % responses. This data is supported by FGD that found very low interested of people to loan credit because of high interest rate, lack of experience and information of microfinance.

As Table 3 shows the components of social capital show statically significance association between agro ecological areas and household's get help from other people in the community if he/she need with Pearson chi square values, degrees of freedom and probability are 18.671, 4 and 0.001 respectively at 0.01 level of significance. However, the same is no true the case of the components general trust people in the community and participated in group activities like 'Debo/Wenfel'.

In terms of inter-site comparison, Lay Alawuha scored higher on household's get help from other people in the community if he/she need than Weyiney and Bekelomankiya.

Access to physical capital is expressed in terms of respondents having access to agricultural technology, transport, energy and household goods. The results (as per Table 3) show statistically significant relationships across agro ecological areas for donkey/ horse cart for transport with Pearson chi square values, degrees of freedom and probability are 9.819, 2 and 0.007 respectively at 0.01 level of significance. Laye Alawuha reports more horse cart for transport compare to the two other sites.

While kerosene for energy is also statistically significant relationship with agro ecological area with Pearson chi square values, degrees of freedom and probability are 12.6, 2 and 0.002 respectively at 0.01 level of significance. The highest score indicated for kerosene as energy source in Laye Alawuha whereas the least score reported in Bekelomankiya.

In addition these two physical capital, solar and biogas for energy source shows significant association with agro ecological area with Pearson chi square values, degrees of freedom and probability are 17.371, 2 and 0.001 respectively at 0.01 level of significance. Bekelomankiya reported more solar and bio gas source for energy compare to the weyiney sites whereas the least score i.e. no figure reported in Laye Alawuha.

Table 3: Access to livelihood asset by household's

type of household asset	99% CI		
	Chi square	df	P value
Human capital			
Health facility	2.746	2	0.253
Food & income sufficient over the past 12 month	11.236	2	0.004*
Education	7.807	2	0.02
Agricultural training	2.901	2	0.234
Natural capital			
Private pastoral land	6.113	2	0.047
Free grazing land	15.805	2	0.001*
Private plantation of perennial crop	18.528	2	0.001*
Financial capital			
Saving	6.187	2	0.045
Credit (formal, informal)	27.431	2	0.001*
Remittances	1.943	2	0.379
Wage	5.519	2	0.063
social capital			
General truest people	4.615	4	0.323
Get help from other people	18.671	4	0.01*
Participated in group activity	9.769	4	0.045

Continue

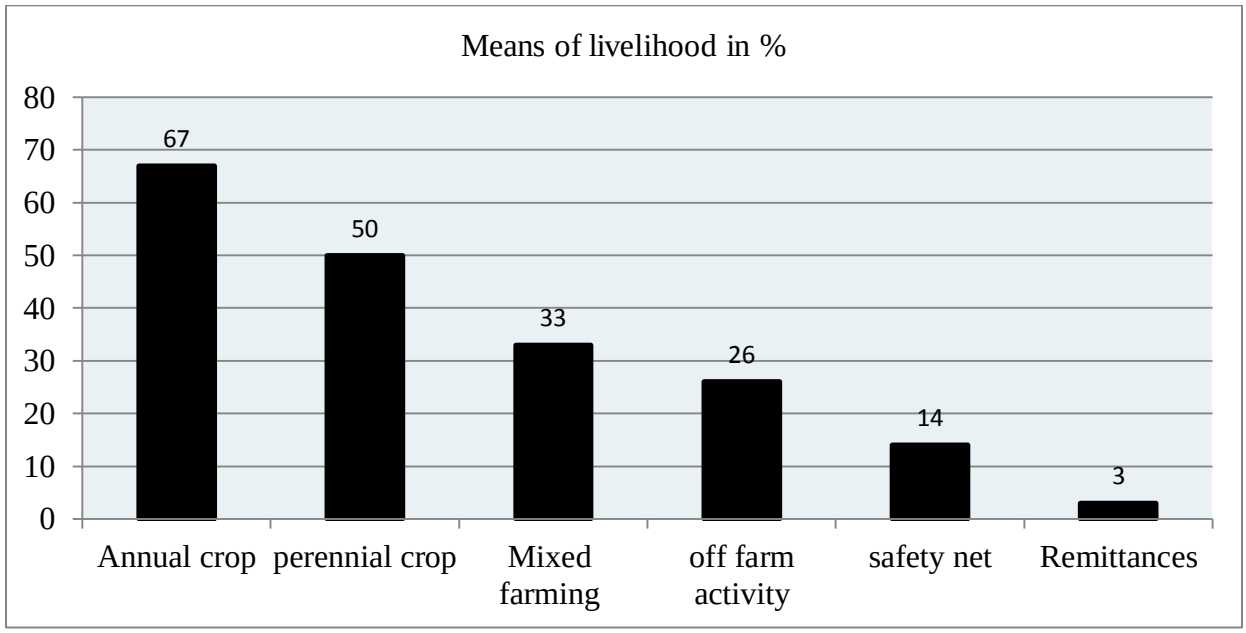
type of household asset	99 % CI		
	Chi square	df	P value
Physical capital			
tools/equipment	1.338	2	0.513
Family drip irrigation	1.464	2	0.481
Irrigation Pump	1.275	2	0.529
Geomemberane	1.275	2	0.529
Transport			
Donkey/horse cart	9.819	2	0.007*
Tractor	3.646	2	0.162
energy			
Electricity	5.609	2	0.061
Kerosene	12.600	2	0.002*
Solar, biogas	17.371	2	0.001*
household goods			
mobile	0.585	2	0.746
radio	3.015	2	0.221
television	1.088	2	0.581
wooden bed	0.153	2	0.926
set of wooden dining table	1.943	2	0.379

* significant association at 0.01 level of significant

source: survey data, February 2018

4.1.2.2. Livelihood option

Apart from livelihood assets, the survey included questions on major livelihood options. Accordingly, respondents were asked to rank livelihood priorities in importance. The major source of priorities are shown in Figure 5.



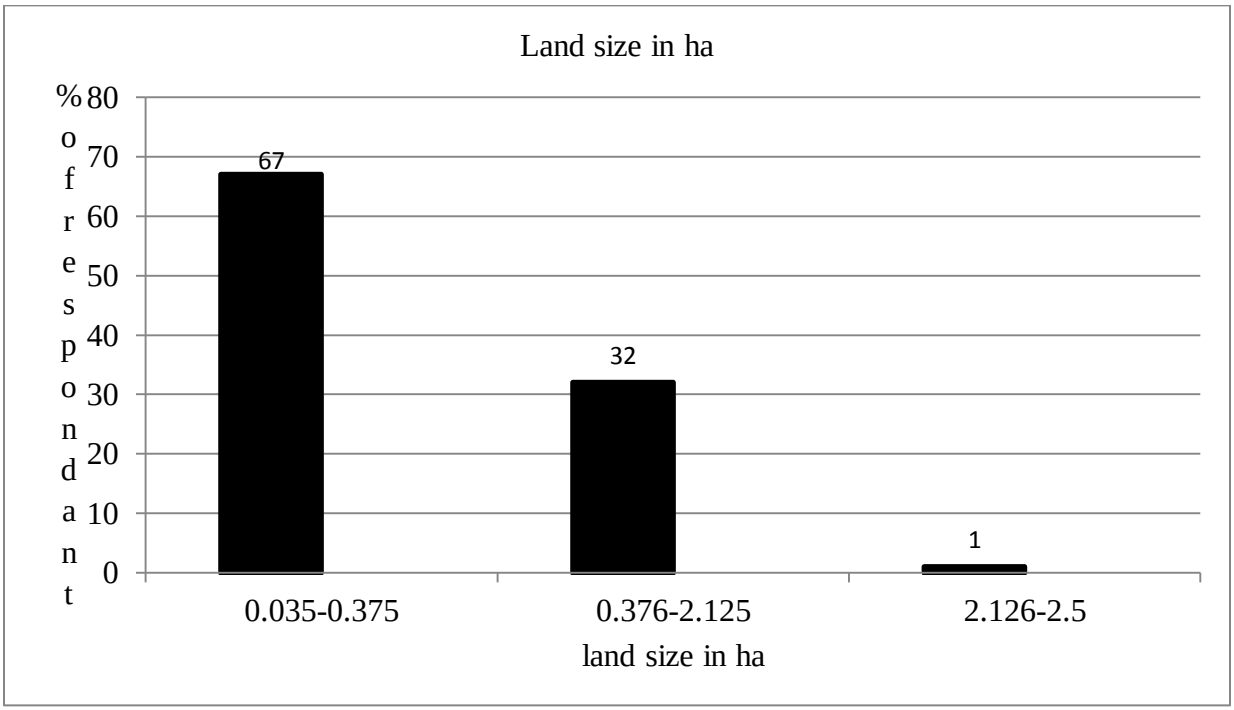
source: survey data, February 2018

Figure 5: Livelihood option

In the study area the main sources of livelihood (which contribute significantly to total food or cash income) were annual crop and perennial crop (Figure 5). The largest percentage of respondents (67 %) indicated that annual crop is the chief source of livelihood (Figure 5). The percentages of respondents depended on perennial crop, mixed farming and off farm activity were 50 %, 33 % and 26 % respectively. About 14 % respondents took part in safety net and 3 % reported taking part in remittances (Figure 5).

Regarding land ownership, the survey results showed that an average household's land holding in the study area is 0.44 ha.

Moreover, 67 % of respondents have a farmland size between 0.035-0.375 hectares while 32 % have 0.376-2.125 hectares. Only about 1 % have 2.126-2.5 hectare of farmland (Figure 6). In most cases in the study area, landholding is small in size except one respondent's that reported as having 2.5 ha.



Source : survey data, February 2018

Figure 6: Land held

4.1.3. Institutions and market aspect

Of the total respondents most 90 % (108) respondents did not get market information from any institutions, and also proportionally small 27.50 % (33) farmers reported as they did not get weekly farm visit from extension workers.

On the other hand, most 87.5 % (100) respondents reported as they have access to all weather roads.

In addition to social service, 47.5 % (47) respondents have reported as they have access to credit whereas slightly more 52.4 % (53) respondents reported less access to credit. In terms of the credit sources, most (96.49 %) respondents reported the main source for the credit is microfinance institutions.

Policy environment is another important component in SLF. According to farmers response, health, forest and education policies were good rated policies in support of climate change adaptation while credit and land use policies were poorly ranked policies(survey data, February 2018).

4.1.4. Vulnerability to climate change

4.1.4.1. Change of climate variability in study area

In the study area most farmers reported that climate change is occurred as a result of increasing such as temperature, frost occurrence, length of dry season and onset or end of dry season; decreasing such as rainfall amount, length of the rainy season and the time for onset or end of wet season. The above results from survey data are supported by results from FGD and interviews with farmers and employer participant. A FGD participant from the highland said: main problem is the frequent occurrences of frost and snow. Farmers in the midlands did not only report drought conditions but also frequent occurrences of frost. In the lowlands, there was confirmed long dry spells and frost. The researcher visited several farms and confirmed, perennial crop affected by frost in all study sites during the visit time.

Table 4: Change for climate variability

variable	response in frequency and percentage		
	Increase	Decrease	Same
Temperature	106(88.3)	14(11.7)	0
Rainfall	2(1.7)	118(98.3)	0
Frequency of frost occurrence	116(96.7)	4(3.3)	0
Length of dry season	113(94.2)	7(5.8)	0
Length of rain season	3(2.5)	117(97.5)	0
End of dry season	114(95)	6(5)	0
End of wet season	4(3.3)	115(95.8)	0

Source : survey data, February 2018

4.1.4.2. Observed changes in livelihood conditions

Most respondents 93 (77.5 %) reported decrease in crop yields, the largest decline was reported in Laye Alawuha followed by Weyiney. Crop varieties and types were reportedly increased in the kola and midlands while some crop or plant species were disappeared. About79.2% (95) respondents reported increase in crop pests and diseases, most of which is reported at Weyiney and Bekelomankiya (Table 5).

In terms of livestock, the study reported decrease in numbers and production. The decline in livestock number was higher in Laye Alawuha and Weyiney than Bekelomankiya. In addition to livestock number, livestock products such as milk, meat and egg have generally declined most in Laye Alawuha kola compared to Weyiney and Bekelomankiya. At the same time, more respondents reported the same in livestock diseases, compared to those who reported an increase and decrease.

In terms of water and soil, most respondents reported declining rainfall amount. The reduction is most pronounced in the midland of Weyiney and highland of Bekelomankiya followed by the lowland of Laye Alawuha (Table 5). A declined amount of Soil erosion is reported by large portion of respondents.

In our survey, respondents reported an increase agricultural income. This income increase from agriculture was higher in Weyiney and Bekelomankiya from the sale of sugar cane and eucalyptus trees respectively. However, decline in income from agriculture was reported in Laye Alawuha as reported decline of food availability in all the three sites. With regard to AEZs, more decline in food availability was reported at Bekelomankiya and Laye Alawuha

In our study as 74 % (115) respondents reported climate change did not create human health impact so far (Table 5).

Table 5: Observed changes in livelihood conditions

	changes in livelihood conditions in frequency and percent		
Reported changes in livelihood	Increase	Decrease	Same
Crops			
crop yield	16(13.3)	93(77.5)	11(9.2)
crop type and variety	62(51.7)	19(15.8)	39(32.5)
crop pests and diseases	95(79.2)	8 (6.7)	17(14.2)
Livestock			
livestock population	6(5)	95(79.2)	19(15.8)
livestock disease	46(38.3)	21(17.5)	53(44.2)
livestock production	8(6.7)	80(66.7)	32(26.7)
water and soil			
Rainfall amount	2(1.7)	118(98.3)	0
soil erosion	33(27.5)	75(62.5)	12(10)
Socio-economic conditions			
agriculture income	50(41.7)	38(31.7)	32(26.7)
food available	29(24.2)	54(45)	37(30.8)
human health	31(25.8)	24(20)	65(52.2)

Source : survey data, February 2018

4.1.4.3. Impact of climate changes

The impact of climate changes is reported to be severe on agricultural crop productivity and on causing crop diseases.

Table 6: Impact of climate change on livelihood activities and related problem

Livelihood activities and related problem	Respondents response in frequency and percent		
	high impact	moderate impact	low impact
Agricultural Crop productivity	119(99.2)	1(0.8)	0
Livestock growth	27(22.5)	92(76.7)	1(0.8)
Forest based product	7(5.8)	39(32.5)	74(61.7)
Cause of Crop diseases and pest	117(97.5)	3(2.5)	0
Cause animal disease	24(20)	94(78.3)	2(1.7)

Source: survey data, February 2018

Apart from impact of climate change on livelihood activities, the research compared the household's wealth rank situation in the previous 5 years from 2009 E.C. As indicated in table 7 60 (50%) of the respondents were reported to be categorized as better off wealth rank due to increasing agricultural output prices, land rent from other farmer, off farm activity employment and outside support from their relatives compared to, 32 (26.7%) households categorized under less wealth rank because of increase living cost, loss of their family member, renting their land for other farmers and land related dispute/conflict in the villages.

Table 7: the well off condition of respondents

situation	respondents in frequency and percent
Better well off	60 (50)
Increasing the agricultural output price	29 (24.20)
land rent from other household	14(11.70)
Off farm activity	12(10.00)
Outside support from relatives	5(4.20)
Less well off	32(26.70)
High inflation (cost of living increase)	15(12.50)
Loss of family member	9(7.50)
Land rent for other household	5(4.20)
Conflict in village land related dispute	3(2.5)

Source: survey data, February 2018

4.1.5. Vulnerable groups to climate change

According to our qualitative survey data, the most vulnerable households with climate change are the poor, youth (especially female and children) and farmers with low agricultural technology and input capability. Similarly, farmers who depend on annual crops are more vulnerable than those depend on perennial crops.

survey data showed that, from agricultural technology applied to farming, the least (below 1%) respondents were used family drip irrigation, irrigation pump and Geomemberane. In addition to this, the farmers also used low agricultural inputs such as improved seed, manure, compost, urea and dap fertilizers 62.5 %, 38 %, 33 %, 68 % and 64 % respectively.

4.1.6. Farmers' Adaptation to Climate Change

4.1.6.1. Coping Mechanisms and adaptation practices to climate change

In this study survey data, FGD and interview revealed that the areas have been subjected to perils of drought, frost and snowfall. Most farmers in Bekelomankiya have been affected by frost and snowfall. However, farmers in Weyiney and Laye Alawuha have been affected by frost and drought. About 73.3 % of the respondents stated that drought brought on them high negative impact by affecting their agricultural crop productivity and livestock growth while 40.80 % of the respondents reported high negative impact brought by frequent occurrences of frost on agricultural crop productivity.

The result from FGD and interview are reported on coping mechanisms (short term response measures) such has seeking relief aid, spiritual solution (pray), reduce the amount of food they consume, fewer meals per day, sold livestock and seeking daily labor work to support people to cope with difficult times in the short term. As shown in Figure 7, the most common adaptation measures were change crop varieties (55%), irrigation (54%), crop diversification (47%) and soil water conservation (31%) followed by reducing number of livestock (28%), shifting planting date (16%) and off farm activity such as trade, labor wage etc (15%).

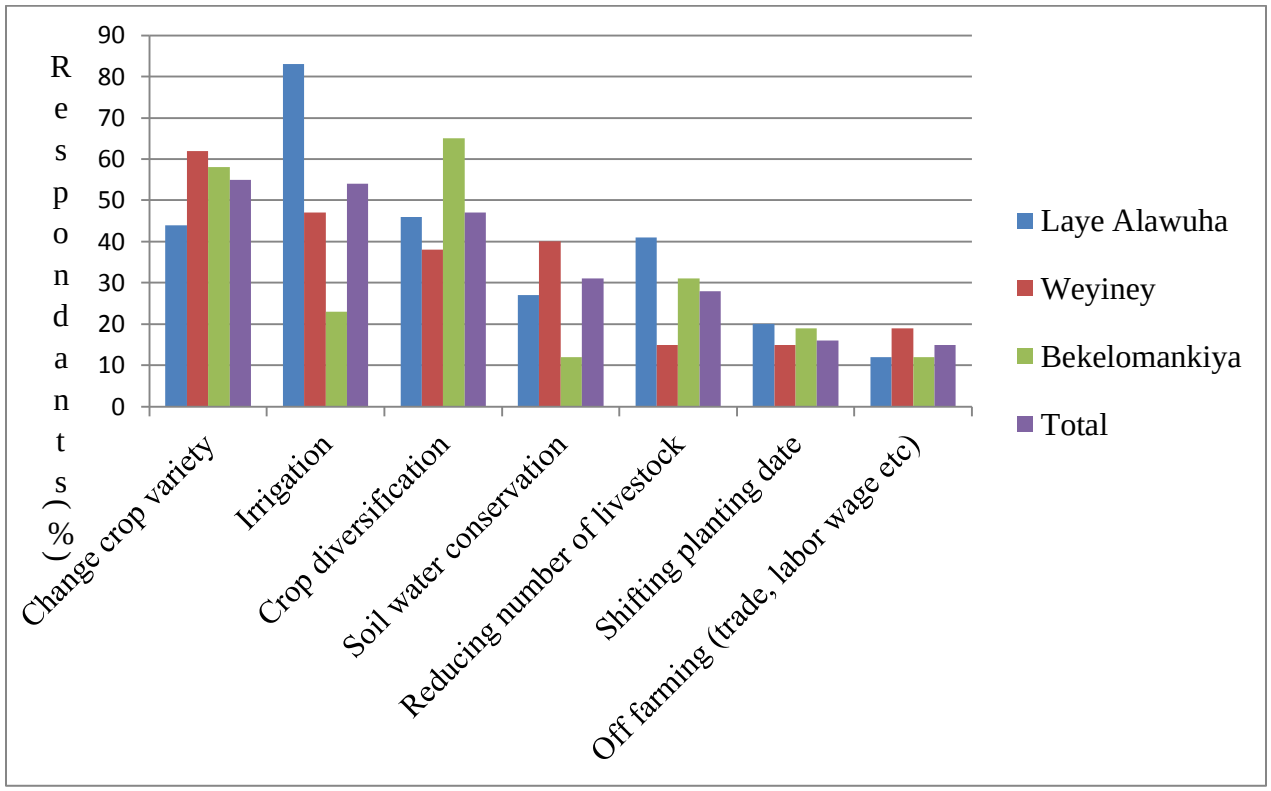
Table 8: Description of adaptation practices

Adaptation practices	Description
Changing Crop variety	Using drought resistant and short maturing verities of crops
Irrigation	using diverting river, constructing pond on farm land, spate irrigation
crop diversification	using different crop type at a time with limited land farm size
Soil& water conservation	Constructed farm bund, water collection ditch,
Reducing number of livestock	they can be sold the livestock during harsh time as saving money in the bank
Shifting planting date	practice includes early and late planting according to the expected rain
Off farm activity	find wage labor, patty trade

Source: survey data, February 2018

Implementation of adaptation practices by farm households varied across the three study area (Figure 7). In the Laye Alawuha kebele, major adaptation measures adopted by farmers included the irrigation (83%), crop diversification (46%) and change crop variety (44%). In Weyiney kebele, change crop variety (62%), irrigation (47%) and soil water conservation (40%) were the

primary adaptation measures. In Bekelomankiya kebele, farmers mainly used crop diversification (65%), change crop variety (58%), reducing number of livestock (31%) and irrigation (23%) as the adaptation measures in a changing climate (Figure 7).

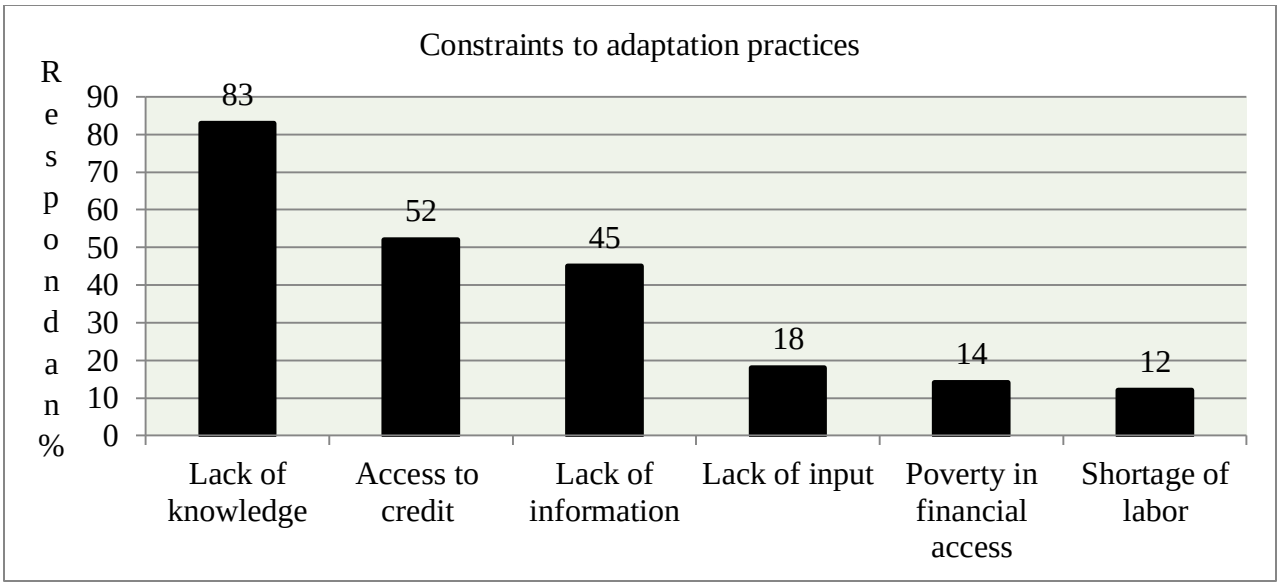


Source: survey data, February 2018

Figure 7: Adaptation practices

4.1.6.2. Constraints and barriers to adaptation

The major constraints identified by the majority of the respondents were lack of knowledge (83%), information (45%), inputs (18%), poverty in financial access (14%), shortage of labor (12%) and access to credit (6%) (Figure8).



Source: survey data, February 2018

Figure 8: Constraints to adaptation practices

4.2. Discussion

4.2.1. Socio economic profile of sampled households

Our study suggested that mostly poor and illiterate households that engaged in small agricultural practices, with other meager socioeconomic characteristics are expected to be challenged by climate change and also unable to fully mitigate and adapt consequences of climate change. According to our study, most people in the study area are categorized under poor wealth status and engaged only in farming, but still there are indications of income differences between farmers in the three study area depending on their livelihood engagement. For Example, farmers living in Weyneye engaged in farming, off farm activities and also practicing perennial crop cultivation like sugar cane, banana, oranges and mango than Laye Alawuha and Bekelomankia. Our study differently from other studies showed that most people in the study areas are living in corrugated iron roof houses like wealthy people doing in other areas (Seyoum, 2015). However,

this is not associated with their life improvement as seen in other areas; it is due to a year to year increase in the cost of thatch grass than corrugated iron in our study area.

4.2.2. Livelihood assets and options

In the livelihood assets, the study showed the households have better access to human and social capital than other assets. In SLF, social capital serve as compensate for a lack of other types of capital. For example, the research finding show that social capital help in reducing transaction cost, i.e. lower monitoring costs of hired labor, easier incentives for pooling resources and better dissemination of information (Ruben and Heras, 2010).

Apart from access to livelihood assets, respondents were asked to rank livelihood priorities and the main sources of livelihood are annual crop and perennial crops that contribute to food or cash income respectively in the study area. Annual crops include wheat, maize, teff, sorghum and barley. Perennial crops are sugar cane, banana, oranges, mango and Eucalyptus tree. However, the small size of the land owned by the farmers, which is below the national average (1.77 ha) of household's land holding in rural areas may influence the productivity of these crops (CSA and WB, 2013). Thus fragmented and small size farm is the main characteristics of smallholder farmers and which has implications on vulnerability and adaptation to climate change. This agrees with the fact smaller land holding farmers will have lesser options to carry out alternative activities on their land (IPCC, 2007).

4.2.3. Institutions and market aspect

Apart from livelihood assets, SLF places emphasis on institutions and markets (DFID, 2001). During our household survey questions dealing with institutions, markets and extension services were asked. However, most farmers responded as they did not get market information from any institution and also didn't have weekly farm visit service from agricultural extension workers.

This results shows for variation in vulnerable include the level of technological development, infrastructure, institutions, and political setups (McCarthy et al., 2001). Similarly, farmers in the study area have reported as they have less access to credit service. The main reasons for minimal credit access according to respondents are high interest rate, lack of experiences, information and less financial deposit in the credit institutions. Considering the fact and the extent that development of infrastructure facilities plays an important role in supporting or hindering adaptation to climate change, respondents were asked about the distance they travel to market and towns, and relatively most of them responded as they have good access to all weather roads.

4.2.4. Vulnerability to climate change

The frequency of climatic variability such as temperature, frequent frost occurrences, length of dry season, onset and end of dry seasons were increase whereas decreases in rainfall amount, length of rain season and end of wet seasons in the study areas. This climate change has its impact on agricultural crop productivity and livestock. Climate related impacts on livelihoods due to increased temperature, frequent frost occurrences, length of dry season and end of dry seasons exert an influence on livelihood asset. Households have given their witnessed increasing temperatures and decreasing rainfall directly affecting agriculture, fodder, land and water resources. However, there are local coping mechanisms (short term response measures) such has seeking relief aid, spiritual solution (pray), reduce the amount of food they consume, fewer meals per day, selling livestock and seeking daily labor work to support people to cope with difficult times in the short term. There are also adaptation measures such as change crop varieties, irrigation, crop diversification, soil water conservation, reducing number of livestock, shifting planting date and off farm activity such as trade, labor wage, though, such mechanisms and measures are not sufficient to address the challenges.

4.2.5. Vulnerable groups to climate change

Societies are vulnerable to climatic shocks, and vulnerability is more acute on the poor, landless, unemployed, using low agricultural inputs and livelihood depends on annual crops. Climate change is more likely to continue to risk the socio economic activities and exacerbate the society's vulnerability. Our FGD showed that most poor farmers depend on relief and safety net program. The poor also depends on daily labor and have low income. Moreover, poor smallholder farmers face inherent vulnerability due to small size or scale of activity and poor access to technologies or poor use of external inputs.

Vulnerability of youth especially female compared to old in this study is only explained by the difference in landholding and absence of employment opportunities. However, old have inherited land to their offspring, they are generally better in landholding and have better immunity to cope with climatic shocks, whereas youth are generally poor because of unemployment and landlessness. Farmer with low agricultural technology and input capability are more vulnerable to climate change. Most farmers in the study areas are used low level of technological development and therefore they are vulnerable to climate change.

Climate change trend continues and the change is more likely to affect agricultural activities and consequently reduce the societies coping range to the future. Particularly drought can be marked by precipitation deficiency that threats the livelihood resources and overall development efforts of nations and specific places through worsening water shortage. Agriculture in general and farming in particular is vulnerable to climate change. Within farming activity, annual crop producers are more vulnerable to climate change than those producing some perennial trees such as sugar cane, Eucalyptus tree etc. Cash crop production, reduce vulnerability means help

farmers in developing resilience to external shocks and increase the overall sustainability of their livelihoods (Seyoum, 2015).

Social impact of climate change is human health related diseases and injuries are introduced especially in hot areas, and become highly prone to disease outbreak (e.g. Miles, 2014). However, our result indicated that there is no impact on human related disease due to intense follow of health care and implementation of proper full extension package.

4.2.6. Farmers' Adaptation to Climate Change

The land preparation obstruction during prolonged drought or rain delay worsens due to the traditional way of farming, land dry up and increased weakness of oxen to plow the land. The heavy rain harm on ripened crop was also exacerbated by the inefficiency of traditional methods to save the harvest (Harun-ur-Rashid & Islam 2007).

The result from FGD and interview are reported on coping mechanisms (short term response measures) such has seeking relief aid, spiritual solution (pray), reduce the amount of food they consume, fewer meals per day, sold livestock and seeking daily labor work to support people to cope with difficult times in the short term. Particular interest in coping mechanism in lowlands and highlands of Guba Lafto is on crop diversification where farmers allot land for perennials crop. In those areas the variation in vulnerability was common between households; households that have perennials crop were better at coping to climatic shock than those who lack it. While smallholder farmer were not confined to only coping measures, they also undertook adaptation actions. The results of the study demonstrated that farm households applied a wide range of adaptation measures in response to the changes in climate. Implementation of adaptation practices by farm households varied across the three study area. However, the major adaptation measures adopted by farmers in the study area included the irrigation, crop diversification and

change in crop variety. The main reason for these adaptations may be due to the presence of ORDA project and Sirinka agriculture research institute for irrigation expansion and short variety seed distribution respectively. Districts with higher irrigation rates are expected to have a higher capacity to adapt to climate challenges and other economic shocks (O'Brien et al., 2004).

The major constraints and barriers such as lack of knowledge related to adaptation measures with their importance and technical aspect ,lack of information and access that deals with weather extreme events, input related problems with supply of improved seed, herbicides and Geomemberane, poverty in financial access and credit are key constraint identified by farmers to implement climate change adaptation measures, even if they plan to adapt to climate variability. Use of farm credit in the study sites is also limited despite the fact, access to microfinance facilities are available at the kebele level. This study is similar to lack of information, lack of money, shortage of labor, shortage of land and poor potential for irrigation as barriers to adaptation in Ethiopia (Temesgen *et al*., 2009).

5. Conclusion and recommendation

5.1. Conclusion

In terms of vulnerability context, the study was identified several factors that play facing problem in smallholder farmers. The study determined climate change related shocks, trends and seasonality such as drought, frequent occurrences of frost and snowfall. Survey household, FGD and interview result reported as increasing such as temperature, frequent frost occurrences, length of dry season and end of dry season whereas respondents response reported as decreases such as rainfall amount, length of rain season and end of wet seasons.

While these climate change has its impact on agricultural crop productivity and livestock. About 99.2 % and 76.71 % of the respondents declared that climate change such as drought, frost brought them high negative impact on agricultural crop productivity and moderate impact on livestock growth respectively while 97.5 % and 73.3 % of the respondents reported on high impact on crop disease, pest and weed and moderate impact on animal disease respectively.

In addition to these climate change, the household's faced socio economic vulnerability of smallholder farmers. The study found that most respondents are poor in wealth status, less land held, absences of employment opportunity, low agricultural technological capability and their main livelihood depends on annual crops. 50 % of the household's found in better well off condition in the last five year from now (2009E.C) due to increasing the agricultural output prices, land rent from other household, off farm activity and outside support from their relatives. However, still the continuity of smallholder farming in Guba Lafto as the way of life remains under uncertain condition.

In terms of livelihood assets, access to social and human capital is relatively higher than other forms of capital, the least one being physical capital.

Therefore, the research finding is identified the most vulnerable are the poor, youth epecially female and children and people with low technological capability. Moreover, those farmers who depend on annual crops are more vulnerable than those perennial crop.

In spite of the above mentioned vulnerability context, people reported taking a number of adaptation measures to cope and adapt to climate change. Thus the study is identified coping mechanisms (short term response measures) such has seeking relief aid, spiritual solution (pray), reduce the amount of food they consume, fewer meals per day, sold livestock and seeking daily labor work to support people to cope with difficult times in the short term.

While most common adaptation measures were change crop varieties, irrigation, crop diversification and soil water conservation followed by reducing number of livestock, shifting planting date and off farm activity such as trade, labor wage etc.

In terms of AEZs, In the kola, major adaptation measures adopted by farmers included the irrigation, crop diversification and change crop variety. In weyenadega, change crop variety, irrigation and soil water conservation were the primary adaptation measures. In Dega, farmers mainly used crop diversification, change crop variety, reducing number of livestock and irrigation as the adaptation measures in a changing climate.

However, the major constraints for agricultural adaptation in study areas were lack of knowledge, information, inputs, poverty in financial access, shortage of labor and access to credit.

5.2. Recommendation

In terms of vulnerability to climate change, the study identified drought, frequent occurrences of frost and snowfall to affect the livelihoods of smallholder farmers. These visible exposure of farmers to climatic stress, low incomes and weak adaptive capacity in the study area is a cause

for worry. Moreover, increasing the cost of living, loss of family member and land rent for other household resulted in less well fare for the households surveyed. As the consequence, farmers are oblique to sold livestock to coping mechanisms and generate income that would support livelihoods at times of climatic stress. Possible measure to increase adaptive capacity of farmers include increasing agricultural production and productivity, using seasonal forecast to inform livelihood planning and using the potential of individuals to be actively involved in the processes of change, in order to minimise negative impacts and maximise any benefits from changes in the climate. Moreover, introducing alternative energy source such as bio fuel, solar energy, electricity etc in study area to sustain the environment. Thus can be reduced existing and future vulnerability of livelihoods.

In terms of adaptation, adaptation to climate change requires knowledge, timely information, finances, labor and inputs. However, in study area survey result showed that the main barrier for adaptation to climate change is lack of knowledge, information, inputs, finance, labor and credits. the possible to avoid these barriers are to improve the technical capacity of farmers and development agent, government should focus on provision of training for farmers and extension agent in how to read and interpret climate change information whereas most of the time, data and information of weather and climate change forecasts are not applicable at local level where many decisions are made about adaptation. Therefore, availability of information should be in useful form. In addition to these, to improve the financial capacity of the farmers government policies should enhance the interest of farmer's and access to affordable credit by adjust interest rate of credit in the micro finance institutions, which will increase their ability and flexibility in response to climate change.

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Annex

Annex 1. Sample size calculation

Yamane (1967) provides a simplified formula to calculate sample sizes.

$$n = \frac{N}{1 + N(e)2}$$

Where

n is the sample size,

N is the population size, and

e is the level of precision.

so the sample size of the research was N= 3025, e= 9 % $n = \frac{3025}{1 + 3025(0.09)2}$=120

Yamane (1967) provides proportionally distributed to the three kebele administrations using the following formula

$$ni = \frac{n \times Ni}{\sum Ni}$$

Where

n = determined sample size the research uses,

ni = households of the ith kebele, and

Ni = total households of the ith kebele

From the above equation to provide proportionality for each kebele

So, Laye Alawuha male= 761 Female= 277 total= 1038

Weyiney male= 994 Female= 331 total = 1325

Bekelomankiya male= 430 Female= 232 total= 662

Sample size for Laye Alawuha $= \frac{120 \times 1038}{3025}$=41

$$\text{Sample size for Weyiney} = \frac{120 \times 1325}{3025} = 53$$

$$\text{Sample size for Bekelomankiya} = \frac{120 \times 662}{3025} = 26$$

Annex 2. Qualitative questions for farmer interviewing and FGD

1. Have you perceived any changes in climate change in your area in the past 10 years?
2. If yes to the above, what are these changes? And which of these changes are more important in terms of their impact on your livelihoods?
3. What aspects of the livelihoods (this may refer to livelihood activities (e.g. agriculture, assets, such as livestock, human capital e.g. health, social capital – e.g. capacity to work together among the community, livelihood outcome, e.g. income from different sources, etc) of the local community are more affected by these climate changes?
4. Compared to other communities around your areas (this may refer to adjacent woredas /kebeles in the same or different agro ecology etc,), do you think your community is more or less vulnerable to climate change?
5. When you consider different groups in your community, do you think there are some groups who are more vulnerable to climate change? If yes, who are these groups? And why are these groups more vulnerable? what the reasons for this difference in vulnerability?
6. Referring to each of the livelihood aspects that were significantly affected by climate change (questions 3 above), how do you tried to adapt to these changes? What do you do to agricultural adaptation to climate change? and what constraint faced to adopt to climate change?

7. Is there a change in incidence of disease in your area as a result of climate change? If yes, what are these diseases? (you can also ask the same about livestock and plant diseases or pests)
8. How do you get modern/scientific information about climate change? (for example, do you listen to radio about weather?)
9. Can you explain about support by government agencies or NGOs regarding problems caused by climate change?
10. Is there anything you want to add about climate change?

Annex 3. Open end questions interview for extension workers and government representatives at kebele level (climate change, vulnerability and adaptation questions)

Name _____ Position _____

1. Do you believe there is climate change in your kebele?
2. If yes, what are the manifestations of climate change in your kebele?
3. What are the solutions to climate change in relation to agriculture?
4. Which groups of people are more vulnerable? why?
5. What are subsistence farmers doing to adapt to climate change?
6. What are the challenges and constraints to adaptation to climate change?
7. How does the government/NGO support subsistence farmers in relation to climate change?
8. Is there anything you want to add about climate change?

Annex 4.open end questions interview for expert and NGOs representatives at zone and woreda level (climate change, vulnerability and adaptation questions)

Name _____ Position _____

1. Do you think there is climate change in the woreda/zone?

2. If you yes, how do you describe the problems climate change in the woreda/ zone?

3. Which kebele/ woreda are more vulnerable to the effect of climate change? Why?

4. Do you assess vulnerability to climate change? If so, how do you determine vulnerability of locations and people?

5. What is the role of your organization in relation to climate change ?

6. Does the government has plans to agricultural adaptation to climate change? If yes, can you explain :.....

.....

7. What are the challenges and constraints to adaptation to climate change?

8. Is there anything you want to add about climate change?

Annex 5.Open end questions interview for sirinqa agricultural research institutes(climate change, vulnerability and adaptation questions)

Name _____ Position _____

1. Do you think there is climate change in our zone?

2. If you yes, how do you describe the problems climate change in the zone?

3. Do you assess vulnerability to climate change? If so, how do you determine vulnerability of locations and people?

4. What is the role of your organization in relation to climate change ?

5. Does your organization has plans to agricultural adaption to climate change? If yes, can you explain :.....

.....

6. What are the challenges and constraints to adaptation to climate change?

7. Is there anything you want to add about climate change?

Annex 6. Quantitative Household survey questions

This research's aim is to determine the vulnerability and adaptation to climate change of farmer livelihood in Guba Lafto woreda. Who are the most vulnerable ?why are vulnerable? and how they are adapt to climate change and identified they faced constraints. Your responses will be treated as private and will be used for research purposes. Thank you for your willingness to discuss with me. Below are my questions to you:

I. General Information

A. Name of household head.....

B. Name of woreda.....

C. Name of Kebele.....

D. Name of village.....

E. Date of interview.....

F. Starting time.....

G. Ending time.....

H. Name of enumerator.....

Part 1: Household characteristics (Answer should be thick like X)

1. What is the sex of the household head? male..... female.....

2.Marital status: Married..... Single..... Divorced.....Widow.....

3. Ethnicity: Amahara.....Other, specified.....

4.Religion: Orthodox Christian.....Muslim.....Catholic Christian.....

Protestant Christian.....Traditional belief system.....Other, specify.....

5. What is your major occupation? Farmer.....farmer and off farm activity

Part 2: Demographic and social characteristics

2.1.Family size: How many people live in your house including the household head? Male..... Female..... Total..... Of this members of households how many of them are dependents (have very little labor/other contribution to production activity/income generation activities of the household)? Male..... Female..... Total.....

2.2. Status (Answer should be thick like X)

2.2.1. Wealth: Poor..... Medium..... Rich..... use secondary data

2.2.2. Type of house Roof.....grass.....other, specify..... by your self

2.3. How well-off is your household today compared with the situation 5 years ago?

less well-off now.....;about the same.....; better off now.....

2.4. If less worse or better-off: can you rank the main reasons for the change? Please rank the most important responses, max 3.

off farm employment.....; land holding (e.g., bought/sold land).....; forest resources.....; output prices (forest, agric,…).....; outside support (govt., NGO,..).....; remittances.....; cost of living (e.g., high inflation).....; war, civil strife, unrest.....; conflicts in village (non-violent).....; change in

family situation (e.g. loss of family member/a major bread-winner).....; illness.....; access (e.g. new road,…).....; other (specify).....

2.5. Social conflict: Have you been involved in the following disputes in the last 5 years? (Answer should be thick like X)

2.5.1. Land related dispute: yes.....No.....

2.5.2. Loan/money related dispute: yes.....No.....

2.5.3. Inheritance related dispute: yes.....No.....

2.5.4. Communal land related dispute: yes.....No.....

2.3.5. Other dispute, specify.....

2.6. Health situation in your family (Answer should be thick like X)

2.6.1.Current incidence of malaria: Very high.....High.....Medium.....Low....

2.6.2. Incidence of water borne diseases (e.g. diarrhea) related to flooding and drought Very high..... High.....Medium.....Low.....

2.6.3. Incidence of respiratory diseases (e.g. TB) Very high.....High.....

Medium.....Low.....

2.6.4. How do you rate your general health well being?

Very Poor..... Poor.....Good.....Very good.....

2.6.5. Sanitation : Open field.....Toilet near home.....other, specify.....

2.6.6. Water supply source for drinking:

Deep wells.....spring.....River.....other, specify.....

2.6.7. Average walking distance to water supply source :

Very far (more than 1 hour)..... Far (between 30 minutes and 1 hr).....Close (between 15 and 30 minutes).....

2.6.8. Access to health services at community health centre/ health station

Very Poor.....Poor.....Good.....Very good.....

Part 3: Livelihood system and assets

3.1. Livelihood system

3.1.1. What are the main sources of your livelihood in order of priority? (answer should be in rank)

- Annual crop.....
- Livestock.....
- Mixed farming and livestock production.....
- Perennial crop such as fruit crop.....
- Forest product.....
- Trade.....
- Off-farm activity.....
- Remittances.....
- Gift in kind.....
- Safety net.....
- Other, specify.....

3.1.2. Income: what was your average monthly income from different source in Ethiopia birr?

3.2. Livelihood assets

3.2.1. Human capital

Did you have access to any of the following in the last year? (answer should be yes or No)

- Health facility in terms of you can use health facility whenever they need them

  yes..... No.....

- Has the household's food production and income over the past 12 months been sufficient to cover what you consider to be the needs of the household? yes..... No.....
- Schools or adult education classes.....
- Trainings/workshops.....
- Others, specify:.....

3.2.2. Natural capital

3.2.2.1. How much land you hold (ha).....

3.2.2.2. Area not used land ....., If yes why?.....

3.2.2.3. Do you have private pasture land? yes.....No.....

3.2.2.4. Do you have community (free) grazing land? yes.....No.....

3.2.2.5. Do you have private plantation of perennial crop (coffee, tree)? yes.....No.....

3.2.2.6. How many you have cow.....; Oxen.....; Goat.....; Sheep.....; Bees.....; Chicken.....; Donkey.....; Mule/horse.....; Camel.....; other; specify..

3.2.3. Financial capital

Did you use any of the following in the last year? (answer should be yes or No)

Savings.....;Investment.....; credit(formal, informal).....;Remittances.....;

Pensions.....; Wage.....

3.2.4. Social Capital (answer should be yes or No)

3.2.4.1.Do you in general trust people in the village (community)?

no.....; partly, trust some and not others.....; yes.....

3.2.4.1.Can you get help from other people in the village (community) if you are in need, for example, if you need extra money because someone in your family is sick?

no.....; can sometimes get help, but not always.....; yes.....

3.2.4.1. Have you participated in group activities like ‘Debo/Wenfel’ or other arrangements in the past 12 months to support a family in the village? No....., yes.....

3.2.5. Physical capital (answer should be yes or No)

Tools or equipment

- Family drip irrigation.....
- Irrigation pump.....
- Geomemberane.....
- Tractor.....

Transport

- Donkey/horse cart.....
- Tractors,
- motor cycle,
- car/truck.....
- Other machinery, specify.....

Energy

- Electricity.....
- kerosene.....
- Solar, biogas, animal dung.....
- Other machinery, specify.....

Household goods

- Mobile.....
- Radio.....

- Television.....
- wooden bed.....
- cupboard.....
- set of wooden dining table.....
- chairs, sofa .....

Part 4: vulnerability to climatic risk

4.1. Have you observed any change in the following climate change related event in recent times/past ten years? (answer should be yes or No)

- Level of Temperature.....
- Amount of Rainfall.....
- Frequency of frost occurrence.....
- Length of dry season.....
- Length of the rainy season.....
- The time for onset or end of dry season.....
- The time for onset and end of wet season.....
- Others, specify.....

4.2. If yes to the above question, how do you describe the type of change for each climate change related event? (answer should be increase or decrease)

Level of Temperature.....;Amount of Rainfall.....; Frequency of frost occurrence.....; Length of dry season.....;Length of the rainy season.....; The time for onset or end of dry season.....; The time for onset and end of wet season.....; Others, specify.....

4.3. If yes to above question , how do you rate the degree of change? (answer should be very low, low, moderate, high, very high)

Level of Temperature.....;Amount of Rainfall.....; Frequency of frost occurrence.....; Length of dry season.....;Length of the rainy season.....; The time for onset or end of dry season.....; The time for onset and end of wet season.....; Others, specify.....

4.4. How do you evaluate the impact of each climate change related event in terms of the following livelihood assets/activities? (answer should be high negative, moderate negative, None, moderate positive, high positive)

Agricultural crop productivity.....; Livestock growth.....; Extraction of forest-based products.....; Incidence of forest vegetation fire, pests/diseases.....; Incidence of Crop disease.....; Incidence of Animal disease.....; Incidence of crop weeds/pests.....; Human disease.....; Others, specify.....

4.5. Considering the above livelihoods assets/activities that are negatively affected by one of these changes, which of them are the most important ones in terms of their degree of influence on your livelihood/household income? (answer should be names according to the ranking of the respondent).....

4.6. What are the most important measures you took to overcome or avoid each of these most important impacts on your livelihood assets/activities indicated in number 4.5 above?

Changed area/place or volume of production/activity.....; Changed type/composition of product/species used to more resistant ones.....; Compensated for the loss by starting new additional livelihood activity.....; Reduced impact of change (e.g

irrigation, change time of activity, stored surplus production, increased fertilizer/purchased food/feed.....; Prevented impact of change (e.g. protective measures such as herbicide/insecticide application, fire protection,).....; Abandoned the activity and shifted to another livelihood activity.....; Others, specify.....

4.7. Have you used/received any of the following resources/support in undertaking the above measures to overcome or avoid the negative impact of climate change related events? (answer should be yes or No)

Credit from CBO/NGO/GO microfinance institutions.....; Material input from the CBO/NGO/GO.....; Income generated from other livelihood activities.....; Labor support from community members.....; Financial loan or material/labor support from relatives/neighbors.....; Technical advice/support on technology/marketing from the CBO/NGO/GO.....; Others, specify.....

4.8 How do you rank the importance of the above resources used or supports received to overcome or avoid the impact of climate change related events?

Credit from CBO/NGO/GO microfinance institutions.....; Material input from the CBO/NGO/GO.....; Income generated from other livelihood activities.....; Labor support from community members.....; Financial loan or material/labor support from relatives/neighbors.....; Technical advice/support on technology/marketing from the CBO/NGO/GO.....; Others, specify.....

4.9. Have you failed to take adaptation measures due to some constraints? (answer should be yes or No)

4.10. If yes to question 4.9, can you indicate the most important constraints that you have faced?.....

Part 5: Agricultural production and production input

5.1. Did you use the water resources for irrigation? yes..... No.....

If answer yes specific water source.....

5.2. Tillage method: Manual with hoe.....Animal traction.....Tractor.....

5.3. Status of your cultivated Land fertility: Highly fertile.....Fertile.....Not fertile.....

5.4. Which agricultural input use in the last year? Manure.....Compost..... Urea.....DAP.....Bio-fertilizer.....Combination of above.....Other, specify.....

5.5. Have you purchased the following input in the last year? (answer should be yes or No) Seed.....Fertilizers.....Animal feed.....Other, specify.....

5.6. What things observed in your live system in the last 5 year? (answer should be increase, decrease or same)

Crop yields.....Crops types and varieties.....Crop pests and diseases..... Livestock populations.....Livestock diseases.....Livestock products.....Rainfall amount.....Water availability.....Soil erosion.....Income from agriculture.....

Food availability..... Human health.....

Part 6: Adaptation strategies

6.1. What adjustments in your farming have you made to climate change adaptation?

6.2. What are the major constraints faced for your implementation of agricultural adaptations to climate change in your farm practices?

6.3. What actions do you take in the face of variable rainfall patterns at (answer should thick X)

Less rainfall: Use fertilizer.....Cattle manure.....Irrigation.....Pond.....

Terracing.....Quick ripening variety seeds.....Flood control..... Afforestation.....other, specify.....

No rainfall/drought: Use fertilizer.....Cattle manure.....Irrigation.....

Pond.....Terracing.....Quick ripening variety seeds.....Flood control.....Afforestation.....other, specify.....

Erratic rains: Use fertilizer.....Cattle manure.....irrigation.....Pond.....

Terracing.....Quick ripening variety seeds.....Flood control..... Afforestation....other, specify.....

6.4. Did you use input supply services in the last 5 year? yes.....No.....

6.5. Did you use market information services in the last 5 year? yes.....No.....

6.6. Did you use extension services in the last 5 year? yes.....No.....

6.7. Did you use health insurance in the last 5 year? yes.....No.....

Part 7.Institutions and markets

7.1. Do you use for information sources? (answer should thick X)

Radio: yes.....No.....; TV: yes.....No... .; Newspaper: yes.....No..... other, specify.....

7.2. How do you rate weather related information? (answer should thick X)

7.2.1. Is information timely and adequate? Poor.....Average.....Good.....

7.2.2. Is information frequent or regular? Poor.....Average.....Good.....

7.2.3. Is information useful? Poor.....Average.....Good.....

7.3. Did you attend agricultural training last year? yes.....No.....

7.4. Number of times a development agent visited you per week on average.....

7.5. How is your access road to market, town and school? (answer should thick X)

all weather road.....dry weather road.....

7.6. Did you try to get loan/credit last year? (answer should thick X) yes.....No.....

7.7. If yes, From which source: Government.....Microfinance.....Other, specify.....

7.8. If not, why? High interest rate.....Lack of experience and information.....did not face cash problem.....Lack of deposit..... Other, specify.....

7.9. How do you rate the following government policies in relation to climate change adaptation? (answer should thick X)

- Forest protection: Poor.....Average.....Good.....
- Land use: Poor.....Average.....Good.....
- Credit : Poor.....Average.....Good.....
- Health : Poor.....Average.....Good.....
- Education: Poor.....Average.....Good.....

Those are the questions I have. Thank you for participating in this survey.