SOCIOECONOMIC ASSESSMENT OF COFFEE FARMERS' VULNERABILITY TO THE IMPACTS OF CLIMATE CHANGE IN AGEYO-SETEMA AREA, JIMMA ZONE, SOUTHWESTERN ETHIOPIA

M.Sc. THESIS

TIGIST YISAHAK BALCHA

January 2015

Jimma University

SOCIOECONOMIC ASSESSMENT OF COFFEE FARMERS' VULNERABILITY TO THE IMPACTS OF CLIMATE CHANGE IN AGEYO-SETEMA AREA, JIMMA ZONE, SOUTHWESTERN ETHIOPIA

A Thesis Submitted to the School of Graduate Studies Jimma University

In Partial Fulfillment of the Requirements for the Degree of Master of Science in Horticulture (Coffee, Tea and Spice)

BY

TIGIST YISAHAK BALACHA

January 2015

Jimma University

Jimma University College of Agriculture and Veterinary Medicine

Department of horticulture and plant science

Thesis Submission for External Defense Request Form (F-07)

Name of Student: Tigist Yisahak Balcha ID No. 05504/05

Program of study: M.Sc. Horticulture (Coffee, Tea and Spices)

Title: SOCIOECONOMIC ASSESSMENT OF COFFEE FARMERS' VULNERABILITY TO THE IMPACTS OF CLIMATE CHANGE IN AGEYO-SETEMA AREA, JIMMA ZONE, SOUTHWESTERN ETHIOPIA

I have incorporated the suggestion and modifications given during the internal thesis defense and got the approval of my advisers. Hence, I hereby kindly request the Department to allow me to submit my thesis for external thesis defense.

Tigist Yisahak Balcha ________________

Name signature of student

We, the thesis advisers have verified that the student has incorporated the suggestions and modifications given during the internal thesis defense and the thesis is ready to be submitted. Hence, we recommended the thesis to be submitted for external defense.

Major Advisor: Tino Johansson (PhD) ________ 05/01/2015

Name Signature Date

Co-Advisor: Weyessa Garedew (Associate Professor) ____________ ______________

Name Signature Date

Decision/suggestion of Department Graduate Council (DGC)

____

______________________ __________

_____________ Chairperson, DGC

Signature Date ______________________

__________ ___________ Chairperson, CGS

Signature Date

DEDICATION

I make this special dedication to my family specially my mother Almaz Hayile. This is in remembrance of their numerous financial sacrifices, prayers and moral support to ensure the realization of my academic achievements.

STATEMENT OF THE AUTHOR

I hereby declare that this thesis is my original work and that all sources of materials used in this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for M.Sc. degree at Jimma University College of Agriculture and Veterinary Medicine and is deposited in the University Library to be made available under the rules of the library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma or certificate. Brief quotations from this thesis are acceptable without special permission, provided that accurate acknowledgement of the source is made. Requests for permission for comprehensive citation from, duplicate of this manuscript in whole, or in part may be granted by the Department of Plant Science and Horticulture or the School of Graduate Studies of Jimma University, when in his or her decision the proposed use of the material is in the interests of scholarship. In all other occurrences, permission must be obtained from the author.

Name: Tigist Yisahak Balcha Signature: ----------------

Place: Jimma University College of Agriculture and Veterinary Medicine, Jimma
Date of Submission:

BIOGRAPHICAL SKETCH

The author Tigist Yisahak was born in Jimma, in 1987. She studied her Elementary and Junior School in Seto Semero Secondary and Senior Comprehensive Secondary School, high school grade 9 and 10 at Jimma Jiren Secondary School and preparatory at Jimma Academic and Vocational School from September 1992 to June 2003 . Soon after, she joined Mekele University in December 2004 and graduated with a BSc degree in Dry land Crop and Horticulture in July 2006/07. She was employed by the Southern Nations Nationalities and People Regional State and stationed at Boloso Sore Rural Development Office to work as food security project coordinator in 2007, and served until June 2010. In October 2011, the author joined the Jimma Zone Limu SekaWoreda Rural Development Office to work as Agronomist then irrigation expert for horticultural crops. She joined the School of Graduate Studies (SGS) of JUCAVM in October 2013 to pursue her graduate studies in Horticulture.

ACKNOWLEDGEMENTS

I wish to thank the Almighty God for his protection throughout the period of my life time. I would like to express my sincere gratitude and heartfelt thanks to my major Advisor: Tino Johansson (PhD) and Co-advisor Weyessa Garedew (Associate Professor) for their invaluable comments, skillful supervision and materials contributions which enabled me to complete this research work successfully. Starting right through proposal preparation their critical technical guidance, evaluations of the thesis research and constructive comments were quite useful and are gratefully acknowledged.

My sincere thanks and appreciation also go to Development Agents and Kebele Administrators' in the study site for their absolute cooperation. I also appreciate and show appreciation to my friends Mr. Solomon Fantaw, Mr. Mehari G/Michael, Mr. Wondwossen Ayalew, Mr. Gashaw Guben, Miss. Nigat Tessema, Mr. Muez Mehari, Mr. Girma Eshetu, Mr. Destalem Gebremicael, Mrs. Meaza Hafiz and Mr. Abiyot Hunde.

At the same time Jimma University College of Agriculture and Veterinary Medicine (JUCAVM) for their absolute, facilities and creating a superior learning environment. Exceptional thanks are reserved to department of Horticulture and Plant Sciences and School of Graduate studies. Mr.Fekadu Mitiku, Mr. Zekariyas Shumete and Adugna Eniyew, instructors at JUCAVM, are also heartily acknowledged for their comments and suggestions on the thesis.

My profound gratitude goes to the Climate Change Impacts on Ecosystem Services and Food Security in Eastern Africa (CHIESA) project funded by the Ministry for Foreign Affairs of Finland for offering me the scholarship to undertake the thesis work and providing me the MSc thesis research grant. Also CHIESA scholars and colleagues in the work package 7 : Sarah Murabula, Lilian Kwamboka, Brenda Monchari,Irene Kibona, Girma Eshetu and Kelvin Chrispin are highly acknowledged in contributing on designing the questionnaire for household survey. Lastly, but not the least, I would like to express my sincere gratitude to my family and my mother Mrs. Almaz Hayile and my sisters Mrs.Chaltu Yisahak,Mrs.TarikYisahak and my brother in-low Mr. Asnake Endashaw for their prayers and inspiration towards achieving this goal.

ABRIVATIONS AND ACRONYMS

AWZ………………………..Agro-ecological Zones

CEEPA……………………. Center for Environmental Economics and Policy in Africa

CHIESA……………………Climate Change Impacts on Ecosystem Services and Food Security in Eastern Africa

CSIRO…………………..…Commonwealth Scientific and Industrial Research Organization

FAO………………………Food and Agriculture Organization

GCMs……………………...Global Circulation Models

GDP……………………….Gross Domestic Product

GDP………………………Gross Domestic Product

HHC………………………...Household Characteristics

IFPRI……………………….International Food Policy Research Institute

IPCC ……………………...Intergovernmental Panel on Climate Change

NCAR………………………National Center for Atmospheric Research

NMS………………………National Meteorological Services

PCA……………………….Principal Component Analysis

SRES………………………Special Report on Emission Scenario

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF TABLES IN THE APPENDICES

LIST OF FIGURES IN THE APPENDICES

ABSTRACT

Despite the fact that climate change affects Ethiopian agriculture, there has been a limited research done on impact assessment. There is a limited availability of socioeconomic assessments of coffee farmers' vulnerability to those impacts. In respect to this limitation, this study focuses on the socioeconomic assessment of coffee farmers' vulnerability at the household and kebele level, their perception and experience of past climate-driven events that have happened due to climate change. A sample size of 300 coffee farmers were selected by proportional purposive random sampling method from Setema, Diffo and Ageyo for survey and a total of 20 farmers from each kebele with equal number of male and female were invited to focus group discussion. Descriptive statistics was used to analyze: farmers' perception and experience on past climate shocks events in the study area. Integrated vulnerability analysis approach was employed to develop indexes. The indicators have been classified into adaptive capacity, exposure and sensitivity to climate change impacts. Then principal component analysis (PCA) was used to construct and compute vulnerability index for each kebele. Households with selected socioeconomic characteristics such as low level of education, limited participation in social safety nets (social-networks), more dependents in the household and old age of the household head are more vulnerable to the impact of climate change. Result from PCA showed that 51% of coffee farmer households were highly vulnerable, 19% households were moderately vulnerable and 30% households were less vulnerable the result from the agro ecology analysis shows that coffee farmer households living in Setema (the highland part) were highly vulnerable, farmers in Ageyo (low land part) were moderately vulnerable and farmers' in Diffo (middle altitude zone) were less vulnerable. Vulnerability index for the kebeles were -1.07,-0.92 and 1.28 for Setema,Ageyo and Diffo respectively. This is due to difference in the level of adaptive capacity of the households and based on different altitudinal zones. Result from perception of farmers' and focus group discussion shows that in the study area the temperature is increasing while precipitation is decreasing and there is more erratic rainfall pattern and disease infestation on coffee in the study area which forces the farmers' to change their agricultural practices. To cope with the impact of climate change vulnerability the adaptive capacity of the farmers needs to be strengthened. Future line work should focus on household by using different indicator models to assess the level of vulnerability of households to the impact of climate change and using time series data of coffee yield with socioeconomic characteristics of the farmers along altitudinal gradient in order to identify which socioeconomic characteristics is affected by climate change and affect yield and make the farmer more vulnerable.

Keywords: Climate change vulnerability, coffee farmers, Perception, principal component analysis.

1. INTRODUCTION

Agriculture is the dominant sector in the Ethiopian economy. It contributes to about 42–45 % of gross domestic product (GDP), generates more than 85 % of foreign exchange earnings, and employs more than 80 % of the population (Zenebe *et al*.,2011). The contribution of the agricultural sector to the total economy, however, is challenged by its vulnerability to climate change.

"The climate of the continent is controlled by complex maritime and terrestrial interactions that produce a variety of climates across a range of regions, e.g., from the humid tropics to the hyper arid Sahara" (Christensen *et al*., 2007). Climate applies a significant control on day-to-day economic development of Africa principally for agricultural and water resource sectors, at regional, local and household scales. In addition to the backdrop of conventional drivers including economic, biophysical, institutional, cultural and political pressures, primary resource users are estimated to cope with more frequent climate crises such as drought and flood, which increased climate vulnerability (Cooper *et al*., 2008). Volney and Fleming (2000) also mention that environmental degradation such as eroding soils; increased pests and diseases also affect the day-to-day activities of primary resource users (Darnhofer *et al*., 2010).

Results from impacts assessments of climate change on agriculture based on various climate models and special report on emissions scenarios (SRES) indicate certain agricultural areas that undergo negative changes. It is estimated that, by the end of 21st century, parts of the sub Saharan Africa are likely to emerge as the most vulnerable, showing agricultural losses of between two and seven % of GDP. Western and Central Africa are also vulnerable, with impacts ranging from two to four %. Northern and southern Africa, however, are expected to have losses of 0.4 to 1.3 % and have the potential to undermine and even undo progress made in improving the socio-economic wellbeing of East Africana. The negative impacts are also compounded by various factors such as human diseases, high population density, which is estimated to double the demand for food, water and livestock forage in the next 30 years (Mendelsohn *et al*., 2000).

Coffee the most important agricultural product in the Ethiopian economy in which millions of farmers make a living, hundreds of thousands of middlemen are participated in the collection of the crop from farmers and supply to the export and domestic market, and foreign exchange accounting up to 30 % of the total yearly export income is derived from. It is thus a very important agricultural commodity with a significant contribution to the growth and functioning of the economy and the social stability of the country as the main source of the income to tens of millions of small-scale farmers, workers and traders (Ethiopian Coffee Export Association, 2012).

Whilst climate change is just one of numerous factors that may affect global coffee production, the International Coffee Organization considers that it will likely to be one of the most important challenges for smallholders who produce the majority of the world's coffee and are the most vulnerable group. The plant responds sensitively to increasing temperature, especially during blossoming and fructification (Jeremy and Kathleen, 2011). In Ethiopia, smallholders, either cultivating coffee on their own farms or picking semi wild/wild coffee (McMillan et al., 2003). The plant is vulnerable to pests and diseases that reduce the amount and quality of beans and force the grower to allocate resources in order to combat them. Excessive humidity along with high temperatures favors the emergence and proliferation of fungi, while some of them, such as the coffee rust, also thrive where there is a lack of moisture. Moreover, if the temperature is not low enough during the coldest months, vulnerability to diseases also increases.

In Ethiopia the average annual minimum temperature has increased by about 0.25 C^{o} every ten years in the past 50 years while the average annual maximum temperature has increased by about $0.1^{O}C$ (National Meteorological Services Agency, 2001). According to the National Meteorological Services (2007), there has been a very high variability of rainfall over the past 50 years. Even though there has also been a long history of drought in Ethiopia, studies show that its frequency and spatial coverage have increased over the past few decades (Lautz *et al*., 2003).

These trends of increasing temperature, decreasing precipitation and the increasing frequency of droughts and floods are predicted to continue in the future in the tropics of Africa where Ethiopia is located (IPCC, 2001; Mitchell and Tanner, 2006).The level of vulnerability of different social groups to climate change is determined by both socioeconomic and environmental factors. The socioeconomic factors include the level of technological development, infrastructure, institutions, and political setups (Kelly and Adger 2000; McCarthy *et al*., 2001). The environmental attributes mainly include climatic conditions, quality of soil, and availability of water for irrigation (O'Brien *et al*., 2004). The variations of these socioeconomic and environmental factors across different social groups are responsible for climate change vulnerability.

From the socioeconomic point of view, first, changes in the environment affect consumption of rural livelihoods through their impacts on agricultural production (coffee) and income, since farm yields are directly affected by weather elements (Skoufias and Vinha, 2012)." *Ex ante risk management and ex-post shock coping abilities of the household, respectively, may or may not be able to insulate or smooth consumption from income/yield effects. Given the income risk or shock, some reallocation of resources within the household is also likely to take place*" (Panagiotis *et al*., 2012).

The most commonly used methodological approaches in the climate change literature include the econometric and indicator methods. The econometric method, which has its roots in the poverty and development research, makes use of household level socioeconomic survey data to analyze vulnerability of different social group (Hoddinott and Quisumbing, 2003).The indicator method of vulnerability is based on selecting some indicators from the whole set of potential indicators and of then systematically combining the selected indicators to indicate the levels of vulnerability (Cutter *et al*., 2003).

Even if climate change affects social, economic and environmental systems and shape prospects for sustainable agricultural and rural development, there has been limited research done on the

assessments of climate change impact on coffee production in Ethiopia. Davis *et al.* (2012) indicated that climate change have a profound and negative influences on indigenous Arabica coffee production in Ethiopia. The finding indicated a possible loss of 65-100% in the number of bio climatically suitable localities for indigenous Arabica coffee production in Ethiopia by 2080, under different climate changes scenarios. Deressa *et al*. (2010) and Gutu *et al*. (2012) conducted farmers' vulnerability to the impact of climate change in different agro ecologies using integrated vulnerability assessment in the Nile basin and North Shewa respectively. However, the perception and socioeconomic vulnerability of smallholder coffee farmers' to the impact of climate change has not been addressed yet in Ethiopia in general and at Ageyo-Setema area in particular. Keeping this in views, the present study was carried out based on the following objectives:

- To assess the vulnerability of smallholder coffee farmers to climate change across altitudinal zones.
- To assess and identify socioeconomic characteristics that makes smallholder coffee farmers vulnerable to climate related risks
- To assess climate change perception of smallholder coffee farmers.
- To assess the climate-related shock and impact of climate change on smallholder coffee farmers'.

2. LITERATURE REVIEW

2.1. Definition and Projection of Climate Change

According to Intergovernmental Panel on Climate Change (2001) climate change is "*a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing or to persistent anthropogenic changes in the composition of the atmosphere or in land use*".

"*Increasing fossil fuel burning and land use change have created, and are continuing to create, increasing quantities of greenhouse gases into the earth's atmosphere.* ***These*** *greenhouse gases include carbon (CO_2), methane (CH_4) and nitrogen dioxide (N_2O), and an increase in emission of these gases has caused an increase in the amount of heat from the sun withheld in the earth's atmosphere, heat that would normally be radiated back into space. This increase in heat has led to the greenhouse effect, resulting in climate change. The main characteristics of climate change are increase in average global air temperature (global warming), changes in cloud cover and precipitation particularly overland; melting of ice caps and glaciers; and increase in ocean temperatures and ocean acidity due to seawater absorbing heat and carbon dioxide from the atmosphere"*(UNFCCC, 2007). Global warming is mostly caused by man-made emissions of greenhouse gases (mostly CO_2). According to scientists the largest and fastest warming trend that they have been discern in the history of earth is, that atmospheric concentrations of carbon dioxide increased from a pre-industrial value of 278 parts per million to 379 parts per million in 2005,and the average global temperature rose by 0.74 ^{o}C (UNFCCC, 2007 ; Vitoantonio *et al*., 2008).

The IPCC report (2007) gives in depth projections for the 21st century, which show that global warming will continue and even speed up. The best estimates shows that the earth could warm by 3^oC by 2100. Even if countries reduce their greenhouse gas emissions, the earth will continue to warm. Predictions by 2100 range from a minimum of 1.8° C to as much as 4° C increase in global average temperatures (IPCC, 2007).

2.2. Climate Change and Agriculture

Throughout the 21^{st} century, the global climate is forecasted to be continuing changing. Global circulation models (GCMs) higher mean temperature and changing in rainfall regimes show that there will be radical shift in land use and crop suitability, in addition to increasing vulnerability to climate change variability. Agricultural productivity, farm income and food security will be affected by climate change and variability as well as climate extreme events (Battisti and Naylor, 2009).

There is significant concern about the impact of climate change and it's variability on agricultural production, problem of food security, ecosystem services under risk of dangerous are highlighted in the list of human activities and anthropogenic interference on Earth's climate (Watson *et al*. 2000 ; IPCC 2001).

"*Simulations with Agro-ecological Zones (AEZ) for sub-Saharan Africa suggest a decrease of prime land with highest suitability for crop cultivation; increase in land with moisture stress; and expansion of land with severe climate, soil or terrain constraints, by 30-60 million hectares, in addition to the 1.5 billion hectares already unfit for rain-fed agriculture under current climate. Under the rather dramatic climate changes of scenario Special Report on Emissions (SRES) A2, AEZ computes a decrease of good land (the sum of very suitable and suitable land) under all five General Circulation Models (GCMs) climate projections, by an average of 6.3 %, ranging from 8.2 million hectares National Center for Atmospheric Research (NCAR) to 27.3 million hectares Commonwealth Scientific and Industrial Research Organization (CSIRO). Under the NCAR model, the extent of sub-Saharan land with severe environmental constraints to crop agriculture declines by about 15 million hectares for both the simulated A2 and B2 scenarios, due to significant increases in precipitation and milder* *temperature compared to the other GCM results*" (Fischer *et al*., 2005). Sub-Saharan Africa is much more vulnerable to climate change. This is because Africa's adaptive capacity is extremely low, which is linked to acute poverty levels and poor infrastructure, as reflected in a high dependence on rain-fed agriculture (Brooks *et al*., 2005).

According to the IPCC (2007), mainly the tropics and sub tropics, particularly sub-Saharan Africa's agriculture is adversely impacted by climate change. This means that coffee producing areas have been identified as being at a high risk and needs to make extra efforts to prepare for future, because the rising temperatures are expected to render certain producing areas less suitable or even completely unsuitable for coffee growing that means production may have to shift (Davis *et al*.,2012). Due to this both Arabica and Robusta coffee, producers will be affected by climate change. Predicting global future climate and weather patterns is highly complex in availability of large data. The relationship between crops, atmospheric composition and temperature combined with complexities of world agricultural policies and trade, making predictions about the effects of climate change (International Coffee Organization, 2010; Rachel *et al*., 2007).

In a locality analysis, the most favorable outcome is a reduction in the number of pre-existing bio climatically suitable localities, and at worst an almost 100 % reduction, by 2080. In an area analysis, the most favorable outcome is a 38 % reduction in suitable bioclimatic space, and the least favorable 90 % reduction, by 2080. Based on known occurrences and ecological tolerances of *Coffee Arabica*, bioclimatic unsuitability would place populations in danger, leading to severe stress and a high risk of extinction (Davis *et al*., 2012; https://www.rssl.com/Your-News/Foode-News, 2012).

2.3. Climate Change and Coffee Pest and Diseases

Arabica coffee (*coffee arabica)* and Robusta coffee (*coffee canephora*) are the two main species used in the production of coffee, although the Arabica is by far the most significant, providing approximately 70 % of commercial production (International Coffee Organization, 2012). The productivity (green bean yield) of Arabica coffee is strongly linked to climatic variability, and is thus strongly influenced by natural climatic fluctuations (Camargo, 2010). Optimum mean annual temperature range for Arabica coffee is 18–21 ^{O}C or up to 24 ^{O}C (Ale`gre, 1959). In temperatures above 23 ^{O}C, development and ripening of the fruits enhanced, often leading to the loss of beverage quality (Camargo, 1985), Even irregular occurrence of frost can highly limit the economic success of the crop and excessive humidity, lack of moisture and high temperature favors the existence and spread of fungi such as the coffee rust. Moreover, high temperatures during coldest time increase the crop vulnerability to diseases (Camargo, 1985). The relationship among climatic parameters and agricultural production is more complicated because environmental factors influence the growth and development of the crop in various ways during its growth stages (Camargo, 2010).

Higher temperature (>24ºC) is a promising condition to coffee diseases for example by 2050 the number of days when these conditions are met will increase from 3 to 15 days and vulnerability to disease, fungi such as rust and also pests such as berry borer and other insects will be much higher. Fungal, viral and bacterial diseases will also be more frequent, strong and widespread, as will insect infestations. This cause higher harvest losses and increased costs to withstand the pests and diseases. Also, have significant impact on both production volume and quality. Research suggest that the incidence of pests and diseases, such as coffee berry borer, leaf miner, nematodes, coffee rust will increase as future temperatures rise. The consequent need for more control will make coffee production both more complicated and more expensive (http://www.thecoffeeguide.org/2010).

2.4. Vulnerability to Climate Change

Vulnerability denotes to the ability to be hurt, i.e., the degree to which a system is to be expected to experience harm due to exposure to a hazard (Turner II *et al*., 2003). The scientific use of 'vulnerability' has its bases in geography and natural hazards research, but this term is now a central idea in a variety of research contexts such as natural hazards and disaster management, ecology, public health, poverty and development, livelihoods and famine, sustainability science, land change, and climate impacts and adaptation. Scholars from different knowledge areas and even within the same field conceptualize vulnerability in very different ways. For instance, natural scientists and engineers tend to apply the term in a descriptive way while social scientists tend to use it in the context of a specific descriptive model (O'Brien *et al*., 2004). Timmermann,(1981) suggested, "*vulnerability is a term of such broad use as to be almost useless for careful description at the present, except as a theoretical indicator of areas of greatest concern"*. Liverman (1990) noted that vulnerability *"has been related or equated to concepts such as resilience, marginality, susceptibility, adaptability, fragility, and risk*". Exposure, sensitivity, coping capacity, criticality, and robustness could easily be added to this list. This overall definition points to several contributing components of climate change vulnerability.

Climate change vulnerability is the degree to which a system is unable to cope with adverse effects of climate change: including climate variability and extremes. Is a function of the character, extent, and degree of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2007). Vulnerability, by contrast, is usually represented in negative terms as the susceptibility to be harmed. The central idea of IPCC definition (McCarthy *et al*., 2001) is that vulnerability is degree to which a system is susceptible to and is unable to cope with adverse effects of climate change. In all formulations, the key parameters of vulnerability are the stress to which a system is exposed, its sensitivity, and its adaptive capacity.

It is also defined as the probability that climate shocks will shift household income below a given minimum level (such as a poverty line) or cause income levels to remain below the minimum level if the household is already poor. According to the (IPCC, 2007), a region's vulnerability to climate change depends on its adaptive capacity, sensitivity, and exposure to changing climatic patterns. The level of vulnerability of different social groups to climate change is determined by both socioeconomic and environmental factors. The socioeconomic factors most cited in the literature include the level of technological development, infrastructure, institutions, and political setups (Kelly and Adger, 2000; McCarthy *et al*., 2001).

According to Yamin *et al*. (2005), the disaster community defines vulnerability as conditions that are determined by physical, social, economic, and environmental factors or processes, and that increase the vulnerability of a community to the impact of a threat.(Franklin and Downing, 2004).

2.5. Components of Climate Change Vulnerability

The key components in climate change vulnerability assessment generally include elements of exposure, sensitivity and adaptive capacity (Smit and Wandel, 2006; Carter et al., 2007). Climate change vulnerability is conceptualized and analyzed based on this components and is studied in different sides such as, climate change vulnerability, sensitivity, adaptation and mitigation. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2007).

Exposure: The degree of climate stress upon a specific unit analysis: it may be represented as either long-term change in climate conditions, or by changes in climate variability, including the magnitude and frequency of extreme events (O'Brien *et al*. 2004). The characterization of exposure in the vulnerability literature has often included the stressors as well as the entities under stress (Turner *et al*., 2003; Polsky and Yarnal, 2007).

Sensitivity: The degree to which a system will be affected by climate stimuli. Sensitivity is largely determined by the relationship of individuals, households, or a community to resources impacted by climate events, and by the degree of dependency on those resources. The sensitivity of resource-users to climate change is determined to a large amount by how dependent they are on a climate sensitive natural resource. The more dependent people are on a natural resource, the more sensitive they are to changes in condition or access to the resource. Resource dependency is thus a good measure of climate sensitivity (Marshall, 2011; Marshall *et al*., 2011). Resource-users such as coffee farmers can be dependent on a natural resource in economic and non-economic (social) ways. In brief, those that are more dependent on the resource have less psychological, financial and cultural flexibility with which to experiment with their options for the future (Marshall *et al*., 2012).

Resource users such as producers, farmers, fishermen and loggers can be sensitive to change because of their livelihood attachment to climate change. When a person who has a strong attachment to their occupation is suddenly faced with the prospect that they are no longer able to continue in that occupation, they may not only lose a means of earning an income, they lose an important part of their identity (Lankester, 2012). Hence, individuals with a strong identity created around their resource-based operation are likely to be sensitive to changes in quality, quantity or access to the resource.

Adaptive Capacity : the potential or capability of a system to control to climate change, including climate variability and extremes, so as to moderate potential damages, to take advantage of opportunities, or to cope with consequences. Adaptive capacity is complex. It may be highly affected by a few key features or by a wide range of social characteristics (Supin and Christy, 2011). Adaptive capacity is a description of the potential or preconditions necessary to cope with new situations and enable adaptation without excessively losing options for the future (Nelson *et al*., 2007). It describes the capacity to adapt current resources (financial, physical, human, social or natural capitals) into successful adaptation strategies (Adger *et al*., 2003). Characteristics that contribute to adaptive capacity reflect learning, the flexibility to experiment and adopt new solutions, and the ability to respond generally to a broad range of challenges (Gunderson, 2000; Darnhofer *et al*., 2010).

The capacity to plan, experiment, learn and re organize in the face of change is dependent on novelty, creativity, sharing experiences and possessing the skills to make the most of opportunities (Colding *et al*., 2004; Olsson *et al*., 2008). Without adaptive capacity, any response to climate changes will be sensitive. Climate change will affect the security of individuals and populations as well as the security of states. In social systems, the ability to cope is a measure of the closeness to emotional and financial thresholds (Marshall, 2010). Individuals with emotional and/or financial buffers are better able to absorb the costs of change and adaptation (Lawes and Kingwell, 2012; Marshall *et al*., 2012).

Individuals that have a higher level of interest in adapting to the requirements of the future usually have a higher financial, social and/or emotional flexibility. The level of interest in climate change adaptation can be influenced by climate education and access to climate technology, expertise and information (Marshall *et al*., 2011). People interested in adaptation to change can identify the consequences, impacts and possible responses ("*adaptation options*") to climate change (Howden *et al*., 2007).

2.6. Conceptual Approaches of Vulnerability

"*Based on the objectives to be achieved and the methodologies employed, these differences limit the possibility of having a universally accepted definition and methodological approach to assess vulnerability against which the appropriateness of a given concept or method can be judged. However, the knowledge of the existing conceptual and methodological approaches can guide the choice of one of the methods, or combinations of existing methods, in analyzing vulnerability for a specific area of interest*" (Füssel and Klein 2006 ; Füssel 2007).

Various authors differentiate an 'external' and an 'internal' side of vulnerability to environmental hazards (Turner II *et al*., 2003). Researchers identified biophysical (or natural) vulnerability from social (or socioeconomic) vulnerability, even though there is no agreement on the meaning of these terms (Füssel 2007). Other classifications have been suggested by (United Nations, 2004) physical, economic, social, and environmental factors and by (Moss *et al*., 2001) physical-environmental dimension, socioeconomic dimension, and external assistance. The minimal classification scheme of vulnerability factors is covered by the two largely independent dimensions sphere (distinguishing internal from external factors) and knowledge domain (distinguishing socioeconomic from biophysical factors).

There are three major conceptual approaches to analyzing vulnerability to climate change: the socioeconomic, the biophysical (impact assessment), and the integrated assessment approaches.

2.6.1. Socioeconomic Approach to Vulnerability

The socioeconomic vulnerability assessment approach focuses on the socioeconomic and political status of individuals or social groups (Füssel, 2007). 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 variables cause differences in vulnerability levels. In this case, vulnerability is measured to be an initial point or a state (i.e. a variable describing the internal state of a system) that occurs within a system before it encounters a hazard event (Kelly and Adger, 2000; Allen 2003). Thus, vulnerability is considered to be constructed by society because of institutional and economic variations the socioeconomic approach focuses on identifying the adaptive capacity of individuals or communities based on their internal characteristics.

The main limitation of the socioeconomic method is that it emphases only on variations within society (i.e., differences among individuals or social groups). In reality, societies differ not only due to sociopolitical factors but also to environmental factors. Two social groups having similar socioeconomic characteristics but different environmental attributes can have different levels of vulnerability and vice versa. Generally, this method oversees as exogenous the environment based intensities, frequencies, and probabilities of environmental shocks, such as drought and flood. It also does not account for the accessibility of natural resource bases to potentially counteract the negative impacts of these environmental shocks for example; areas with easily accessible underground water can better cope with drought by utilizing this resource (Deresse *et al*., 2008).

2.6.2. Biophysical Approach to Vulnerability

The biophysical approach assesses the level of damage that a given environmental stress causes on both social and biological systems. For instance, the monetary impact of climate change on agriculture can be measured by modeling the relationships between climatic variables and farm

income (Parry *et al*., 2001). Similarly, the yield impacts of climate change can be analyzed by modeling the relationships between crop yields and climatic variables (Adams 1989; Kaiser *et al*., 1993). Other related impact assessment studies include the impact of climate change on human mortality and health terms, on food and water availability (FAO, 2005), and on ecosystem damage (Forner, 2006).

Most frequently, the damage is estimated by taking climate prediction models (Kurukulasuriya and Mendelsohn 2006) and making indicators of sensitivity by identifying potential or actual hazards and their incidence (Cutter *et al*., 2000). Füssel (2007) identified this approach as a risk-hazard approach and denoted the vulnerability relationship as a hazard loss relationship in natural hazard research, exposure effect relationship in epidemiology, and a damage function in macroeconomics. Kelly and Adger (2000) referred to the biophysical 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*?"

The major limitation is that the approach focuses mainly on physical damages, such as yield, income, and so on. For example, a study on the effect of climate change on yield can show the decrease in yield due to simulated climatic variables, such as increased temperature or reduced precipitation. That means, these simulations can offer the quantities of yield reduced due to climate change, but they do not indicate what that particular reduction means for different people. "*A 50 % reduction in yield due to climate change does not mean the same for the poor farmers that it does for rich farmers*". Poor farmers very often cannot cope with marginal changes in their yields or income, while richer farmers can buffer their loss (smoothen consumption, in technical terms) by depending on savings or sale of some of their assets (Deresse *et al*., 2008). Generally, the biophysical approach focuses on sensitivity (change in yield, income, health) to climate change and oversights much of the adaptive capacity of individuals or social groups, which is more described by their internal characteristics or by the style of entitlements (Derresa *et al*., 2010).

2.6.3. The Integrated Assessment Approach to Vulnerability

The integrated assessment approach combines both socioeconomic and biophysical approaches to determine vulnerability. According to Cutter *et al*., (2000) the hazard of place model show the approach, in which both biophysical and socioeconomic factors are systematically combined to determine vulnerability. The vulnerability mapping approach is the other related example, in which both socioeconomic and biophysical factors are combined to indicate the level of vulnerability through mapping (O'Brien *et al*., 2004).

Füssel and Klein (2006) and Füssel (2007) argued that the IPCC (2001) accommodates the integrated approach to vulnerability analysis. According to Füssel and Klein (2006), the risk hazard framework (biophysical approach) corresponds most closely to sensitivity in the IPCC terminology. Adaptive capacity (broader social development) is largely consistent with the socioeconomic approach (Füssel, 2007). In the IPCC framework, exposure has an external dimension, whereas both sensitivity and adaptive capacity have internal dimension, which is indirectly assumed in the integrated vulnerability assessment framework.

Even though the integrated assessment approach modifies the weaknesses of the other approaches, it has its own limitations. The main limitation of this approach is that there is no standard method for combining the biophysical and socioeconomic indicators. This approach uses different data sets, ranging from socioeconomic data sets (e.g., race and age structures of households) to biophysical factors (e.g. frequencies of drought); these data sets certainly have different and yet unknown weights. Cutter *et al*., (2000) explained that because this analysis neither provides a common metric for determining the relative importance of the social and biophysical vulnerability, nor determines the relative importance of each individual variable, much care is required. The other weakness of this approach is that it does not account for the dynamism in vulnerability.

2.7. Method for Measuring Vulnerability to Climate Change

Vulnerability analysis includes many approaches: the most common methods used in vulnerability assessment are econometric and indicator method. The econometric method has its root in the poverty and development literature. This method uses household level socioeconomic survey data to analyze the level of vulnerability of different social groups (Hoddinot and Quisumbing, 2003). The indicator method is based on selecting some indicators from a set of potential indicators and then combining them to point out the level of vulnerability (O'Brien *et al*., 2004; Brooks *et al.*, 2005).

Indicator method

To calculate the level of vulnerability using indicator method there are two options. The first is assuming that all indicators of vulnerability have equal importance and giving them equal weights (Cutter *et al*., 2000). The other method is assigning different weights to avoid uncertainty. Methodological approaches have been suggested to make up the weights. Some of these approaches include use of expert judgment, principal component analysis (Cutter *et al*., 2003), correlation with past disaster events (Brooks *et al*.,2005). Vulnerability with this approach may be analyzed at local, national (O'Brien *et al*., 2004), regional (Leichenko and O'Brien, 2001; Vincent 2004), and global scale (Moss *et al*., 2001; Brooks *et al*., 2005).

Identification of indicator types and attachments of the scale of analysis is done by international Food Policy Research Institute (IFPRI) and the Center for Environmental Economics and Policy in Africa (CEEPA). As showed in (Table 1), Level of education or literacy rate is a household characteristic (HHC). Similarly, current climate conditions are biophysical (BP) characteristics.

Table 1. Indicators or proxy variables used for vulnerability analysis.

Type of indicator	Indicator	Scale of analysis	References
HHC	Level of education or literacy rate	HH,D,N	Nyong *et al*. 2003 Brooks, Adger, and Kelly 2005
HHC	Age	HH	Nyong *et al*. 2003, Næss *et al*.2006
HHC	Labor unit/consumer unit	HHC	Nyong *et al*. 2003
HHC	Asset, land value, house value(standard	HH,D	Nyong *et al*. 2003 Aandahi and O'Brien 2001
HHC	Household size	HH,D	Nyong *et al*., 2003; O' Brien *et al*., 2004
BP	Current climate	HH,D,N	O'Brien *et al*. 2004
INST	Social networks (member of group or association)	HH	Nyong *et al*. 2003
FC	Crop types, cropping system (mono cropping, multiple cropping),fertilizer or input use	HH	Aandahi and O'Brien 2001
BP	Drought and flood-prone areas	D,N	O'Brien *et al*. 2004
ECO	Income level	HH	
ECO	%age of households below poverty line	D	Aandahi and O'Brien 2001
ECO	Infrastructure	HH,D,N	O'Brien *et al*.2004

Adapted from (Deressa, 2009). Thesis on vulnerability of Ethiopian Agriculture to climate change and farmers' vulnerability.

*Type of indicator: HHC = household characteristic, INST = institutional, FC = farm characteristic, BP=biophysical, ECO = economy**Scale of analysis: HH = household, D = district, N = national

2.8. Farmers perception on Climate Change

Perception on climate change problems and taking action is important for adoption of agricultural technologies Maddison (2006) argued that farmer awareness of change in climate attributes (temperature and precipitation) is important to adaptation decision making. According to Araya and Adjaye, (2001), farmers' awareness and perceptions of soil erosion problem as a result of changes in climate, positively and significantly affect their decisions to adopt soil conservation measures. Well knowledge and farming experience will positively influence farmers' awareness and decision to take up adaptation measures. Improved education and distributing knowledge is an important policy measure for stimulating awareness and local participation in various development and national resource management initiatives (Anley *et al*., 2007). Farming experience improves awareness of change in climate, the potential benefits and willingness to participate in local natural resource management of conservation activities. However, Maddison (2006) indicated that educated and experienced farmers have more knowledge and information about climate change and agronomic practices that they can adopt in response.

2.9. Causes of Vulnerability to Climate Conditions in Ethiopia

Ethiopian vulnerability to climate variability and change is due to very high dependence on rain-fed agriculture, which is very sensitive to climate variability and change, under-development of water resources, low health service coverage, high population growth rate, low economic development level, low adaptive capacity, inadequate road infrastructure in drought prone areas, weak institutions, etc. Vulnerability assessment based on existing information indicated that the sectors most vulnerable to climate variability and change are agriculture, water and human health. In terms of the livelihoods approach, smallholder rain-fed farmers and pastoralists are found to be the most vulnerable. The arid, semi-arid and the dry sub-humid parts of the country are affected by severe drought (Leutze *et al*., 2003).

The vulnerability of Ethiopian farmers to climate change is recognized to their dependence on rain-fed agriculture and high poverty. Rain -fed agriculture, which helps the livelihoods of the majority of the population, is highly sensitive to climate conditions (Deressa *et al*., 2009). The majority of Ethiopian farmers have limited capacities to mitigate, adapt or cope with effects of climate extreme events such as drought, which significantly reduce the already low consumption (Dercon *et al*., 2005). Dercon (2004) indicated that rainfall shocks have a considerable impact on consumption growth, which persists for many years.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The research was carried out in the Ageyo-Setema area which administratively belongs to the Setema and Gumay woredas of Jimma Zone located in Oromia Regional State in southwestern Ethiopia. Geographyically, the study area is located between 8^o 4’ - 8^o 2’ North latitude and 30^o 20’ - 30^o 28’ East longitude at about 450 kilometers away from Addis Ababa, capital city of Ethiopia and 100 km in Northwest of Jimma town. The altitudinal range of the study area is between 1450 and 2400 meters above sea level (m.a.s.l).

Mean annual rainfall is 1695 mm. in the period of 1990 - 2010. The study area has monomodal rainfall distribution In the study area annual average maximum temperature is 27.9 ^{0}C and minimum temperature is 11.9 ^{0}C(JZAO, 2013)

Setema is bordered on the south by Gera Woreda, on the west by Sigmo Woreda, on the north by the Illubabor Zone, and on the southeast by Gumay Woreda. Gumay is bordered on the south by Seka chekorsa Woreda, on the southwest by Gera Woreda, on the northwest by Setema Woreda, on the north by the Dhidhessa River which separates it from the Illubabor Zone.

Agriculture is the main economic activity in the study area. Crop production is mainly rain-fed. Coffee plays a major role in income generation in the area. Maize, teff and sorghum are the major crops grown in the area. Pulses crops, such as, beans and pea are grown to a lesser extent in the area. Southwestern part of the country is believed to be the primary center of origin and center of diversity of *Coffea arabica*, where semi-forest and forest coffee production systems are found. Farming system of the area is mixed farming system. Among 189,575, ha of land covered by coffee plantation in Jimma zone, 2142 ha of coffee farm found in the Setema and 9471 ha in Gumay district (JZAO, 2013). Ageyo-Setema study site was selected by CHIESA project in 2011 as research site because of many reasons. It has a wide range of altitudinal variation, which enables to make some simulation study about climate change. It is also coffee producing area, as

Coffee is one of the major crops considered by the project. The area also known in having high forest biodiversity where one of the work packages is doing their research under the project

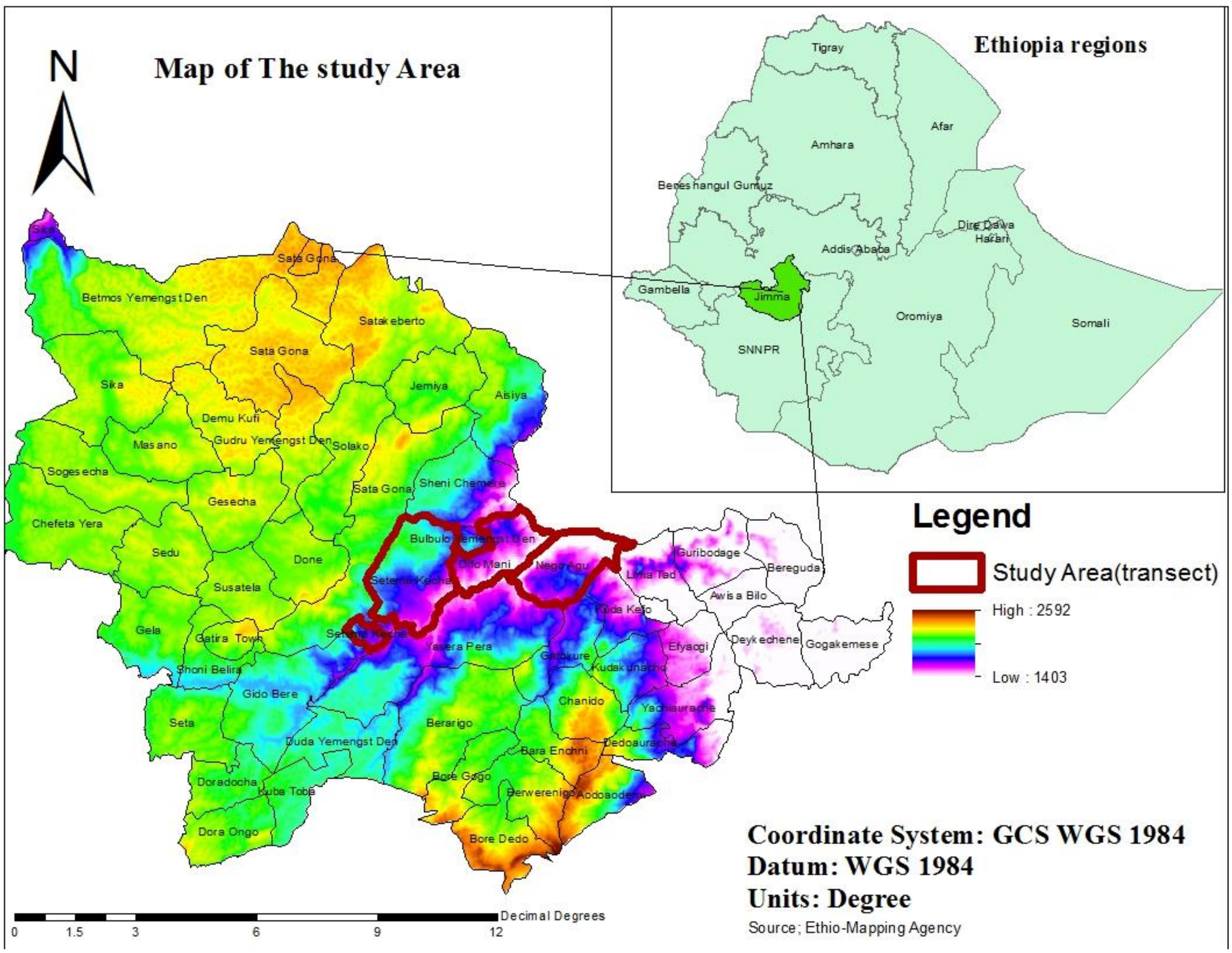


Figure 1. Map of the study area: Ageyo-Setema transect

3.2. Data Collection Methodology.

A total of 2115 (Setema 585, Diffo 924 and Ageyo 606) coffee growers were purposively staratified from the study area. Among which 300 from (Ageyo 86, Setema 83 and Diffo 131) households were proportionally randomly selected for the household survey Structured and semi-structured questionnaire were employed to know climate change vulnerability, farmers perception on climate change and climate and non-climate - related shock identification and impact assessment. (Appendix Table 1). Focus group discussions were conducted in the area by selecting 20 farmers from each kebele to understand past disaster climate event. Farmers who have awareness about climate change, community leaders and representatives of the community were selected . Male and Female groups were discussed separately to minimize biasness among gender (Appendix Figure 2). The farmers draw a map to identify good years as well as bad years depending on their perception related to climate change and the events that have been happened in that specific years and risk (outcome of the climate shock event) (Appendix Figure 1). Secondary data were collected from reviews among selected literature statistics and censuses, and rainfall data for the transect was collected from Jimma meteorological station.

Sample size were determined based on (Cochra, 1977) formula

$$no = \frac{Z^2 * (P)(q)}{d^2} \longrightarrow n_1 = \frac{no}{(1 + no / N)}$$

Where; n_o = Desired sample size Cochran's (1977) when population is greater than 10000

n_1 = Finite population correction factors Cochran's (1977) when population less than10000

Z = Standard normal deviation (1.96 for 95% confidence level)

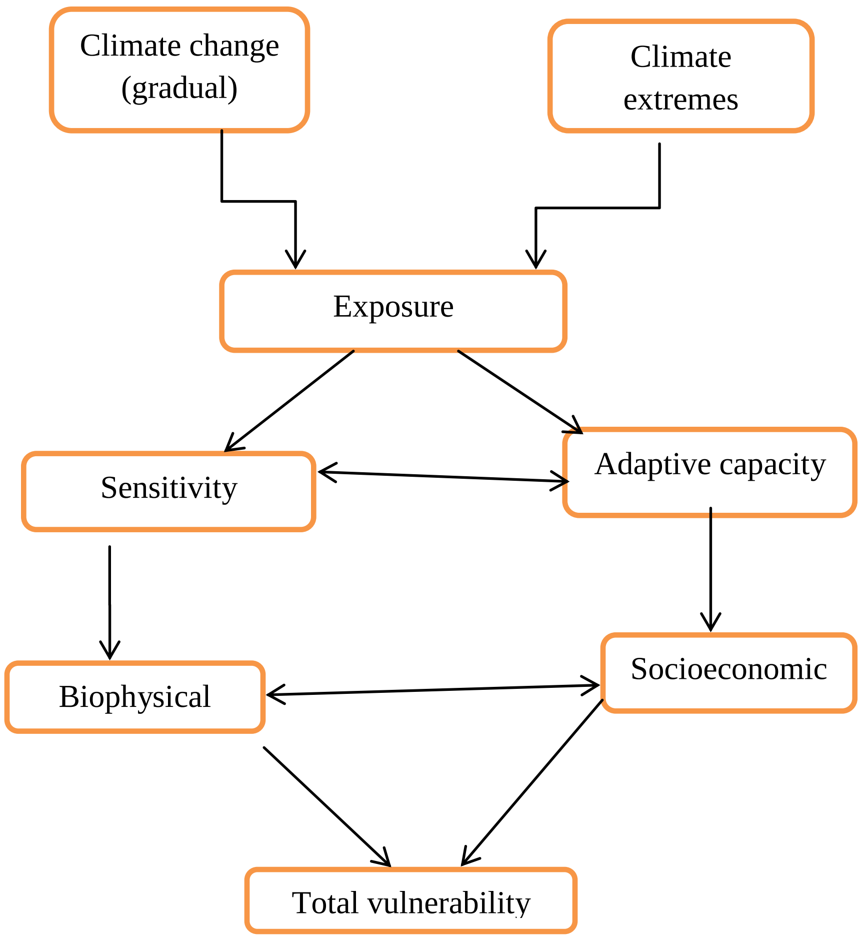
P = Proportion of population to be included in sample (% = 0.38) 38% for this study

q = 1-P i.e. (0.9) N = Total number of population

d = Degree of accuracy desired (0.05)

3.3. Theoretical Frame Work for the Study

The IPCC's (2007) definition of vulnerability was used for this study by adapting it to the Ethiopian context. As indicated earlier, because the IPCC definition accommodates the integrated vulnerability assessment approach. This study was based on that approach, which considers both the biophysical and the socioeconomic indicators in assessing vulnerability.



Source: IPCC, (2007)

Figure 2. Theoretical framework of the study.

Farmers in the study transect are exposed to both gradual climate change (temperature and precipitation) and extreme climatic events (mainly drought and erratic rainfall). Exposure affects sensitivity that is exposure to climate risk affect outcome (yield and income). Exposure is also linked with adaptive capacity. Sensitivity and adaptive capacity are also linked; the adaptive capacity influences the level of sensitivity. On the other hand, higher adaptive capacities (socioeconomic vulnerability) decrease sensitivity (biophysical vulnerability) and vice versa. Therefore, sensitivity and adaptive capacity add up to total vulnerability.

3.4. Model Variables

The model variables for this study were categorized according to the study conceptual framework for this study:

Adaptive capacity: is represented by socioeconomic characteristics which are availability of infrastructure and institutions,technology, wealth, use of improved coffee varieties, age, sex literacy rate, social safety nets (Cutter *et al*.,2000). Ownership of radio and quality of residential homes are commonly used as indicators of wealth in rural African communities (Langyintuo, 2005; Vyas and Kumaranayake, 2006). These were also used as indicator of wealth in this study

Sensitivity: is the degree to which a system is affected, either harmfully or helpfully, by climate change stimuli (IPCC, 2001). For this study frequency of climate extremes such as erratic rainfall pattern, frequency of drought and plant disease are used as sensitivity factors because this factors make the agricultural sector to yield reduction as well as reduce in income.

Exposure: Is the nature and degree to which a system is exposed to climate variations; increasing temperature and decreasing precipitation are both damaging to the already hot and water scarce African agriculture (IPCC, 2001). Thus, areas with increasing temperature and decreasing rainfall were identified as more exposed to climate change.

3.5. Vulnerability Assessment

To measure farmers' vulnerability to the impact of climate change the integrated approach that is both biophysical and socioeconomic approach were analyzed for the indicators of Exposure, Sensitivity and Adaptive capacity showed in (Table 2).

Exposure taken for this study were climate extreme shocks which have been happened to the households in the past 10 years such as erratic rainfall, drought, below average rainfall and so on, other shocks which are non-climatic change shocks and variability such as wildlife damage on crop due to ecosystem disturbance, animal and plant disease, and other indicator for exposure chosen were annual average precipitation for the study area.

Sensitivity is given by the degree to which a system is modified or affected by an internal or external disturbance or set of disturbances (Gallopin, 2003). Indicators used as sensitivity of vulnerability assessment were erratic rainfall impact, drought impact, precipitation impact.
Adaptive capacity of a household was taken to be an emergent property of livelihood assets, which is physical, human, natural, financial, and social. These indicators do assist households to combat climate shocks through risk pooling, risk distribution or as a buffer during extreme climatic events were selected in this study.

Table 2 Indicators of Exposure, Sensitivity and Adaptive capacity for the study

Component of indicator of Exposure	**Description of Indicators**
Erratic Rainfall	Frequency of erratic rainfall in the past 10 years
Drought	Frequency of Drought in the past 10 years
Below average rainfall	Frequency of below average rainfall in the past 10 years
Loss of top soil (Soil Erosion)	Frequency of Soil erosion in the past 10 years
Minimum temperature	Rate of change in average annual min temperature from 1993-2011
Mean annual precipitation	Rate of change in average annual precipitation from 1979-2012
Insect pest attack on crop and Coffee before harvest	Frequency of insect pest damage on crop in the past 10 years
Plant disease	Frequency of plant disease in the past 10 years
Animal disease	Frequency of animal disease in the past 10 years
component of indicator of Sensitivity	
Impact of Erratic rainfall	Amount of loss on crop or income
Impact of erosion	Amount of loss on crop or income
Impact of drought shock	Amount of loss on crop or income
Impact of bellow average rainfall	Amount of loss on crop or income
Impact t of precipitation and annual mean min temp on coffee production	Loss of yield and income on coffee
Impact of wildlife damage to crop	Amount of loss on crop/asset or income
Impact of plant disease	Amount of loss on crop or income
Impact of animal disease	Amount of loss on crop or income
Component of indicator Adaptive capacity	
Household characteristics	Age, sex and highest level of education of household head
Socioeconomic characteristic	Income from different source, group in social safety nets access to weather forecast, market, school and electricity
Asset of households	Land holding and size of coffee farm, roof material of main dwelling, availability of radio, cellphone in the household

Source: Owen compilation data from survey Ageyo-Setema 2014/15

3.6. Calculation of The Vulnerability Index

After chosen the suitable indicators, now these need to be normalized so as to bring the values of the indicators within the comparable range (Vincent, 2004; Gbetibouo and Ringler, 2009 ; Nelson, *et al*., 2010). Normalization was done by subtracting the mean from the observed value and dividing by the standard deviation for each indicator (Table 3.)(Luni *et al*., 2012)

$$Normalized\ value = \frac{Observed\ Value - Mean}{Standard\ devation}$$

Assigning weight by Principal Component Analysis (PCA) following Deressa *et al*. (2009) and Gutu *et al*. (2012), is thus preferred compared to the former two methods (Cutter *et al*.,2003; Gbetibouo and Ringler, 2009 ; Nelson *et al*., 2010).

PCA was run for the selected indicators of exposure, sensitivity, and adaptive capacity separately. The loadings from the first component of PCA were used as the weights for the indicators. The weights assigned for each indicator varies between -1 and +1, sign of the indicators denoting the direction of relationship with other indicators used to construct the respective index. The magnitude of the weights defines the contribution of each indicator to the value of the index.

The normalized variables were then multiplied with the assigned weights to construct the indices (for exposure, sensitivity, and adaptive capacity separately) using this formula (Luni *et al*., 2012).

$$I_j = \sum_{i=1}^{k} b_i \left[\frac{a_{ji} - x_i}{s_i}\right]$$

Where, **‘I’** is the respective index value, **‘b’** is the loadings from component from PCA taken as weights for respective indicators, **‘a’** is the indicator value, **‘x’** is the mean indicator value, and **‘s’** is the standard deviation of the indicators.

Finally, vulnerability index for each household is calculated as:

$$V = (AC) - (S + E)$$

Where, **“V”** is the vulnerability index, **“E”** the exposure index, **“S”** is the sensitivity index and **“AC”** is the adaptive capacity index for respective household.

3.7. Statistical Analysis

Statistical analysis procedures used for this study were principal component analysis, descriptive statistics, frequency, chi-square test and correlation.

Principal component was analyzed by data reduction factor analysis in order to generate weights and construct vulnerability indices. Eigenvalue-one criterion or Kaiser Criteria was used for determining the number of components. Based on this, number of meaningful components was retained with an eigenvalue greater than 1.0 (Kaiser, 1960). Large loading was considered according to Stevens (1986) with absolute value exceeds 0.40. Descriptive statistics such as frequency and was used for the socioeconomic and biophysical vulnerabilities, to indicate adaptive capacity, sensitivity and exposure for each household, climate-related and non-climate-related shocks and there influences, farmers perception on climate change and the past disaster events due to climate change in Ageyo-Setema. Correlation analysis was used to see the association of the socioeconomic variables (indicators) with the climate extreme variables and climate related impacts.

All the analysis was done using SPSS version 20 software.

4. RESULTS AND DISCUSSIONS

4.1. Demographic and Socioeconomic Characteristics

Most farmers in the survey area depend on agriculture for their livelihood because access to off-farm activities was limited. The mean family size was 6.21, 5.77 and 5.76 for Setema, Diffo and Ageyo respectively with a minimum of 1 member and maximum of 16 members in the household. The mean age of household head for the study area was 36 years, with minimum and maximum age of 20 and 90 years, respectively and the standard deviation for age was ±13.8, ±14.09 and ±11.69 for Setema, Diffo and Ageyo respectively. The survey result indicated that 49 % of respondents had completed primary education while 38 % of the respondents have no formal education. Only 11 % of the respondents had completed secondary education (Appendix Table 2). The surveyed households in the study area have low educational level, which might not help them to reduce vulnerability in future generations even though education is an important way to cope with climate change impact and makes the farmers more vulnerable to climate shocks. The present result agrees with (Putnam, 2000; Cutter, 2001; Tierney, *et al.*, 2001; Deressa *et al*., 2010) who reported that lack of access to resources (including information, knowledge, and technology) is some of the major factors that influence social vulnerability.

Age is an important consideration as the farmers in the study area with old age groups were vulnerable comparatively than that of younger. This is in agreement with O'Brien and Mileti (1992) and Vincent (2004). The economic wellbeing, stability and structure of the population being important in the resilience of populations to environmental shock, and may play a key role in determining climate change vulnerability. The current study result also agrees with Abimbola *et al*.(2013) who reported that aged cacao farmers' in Osun state, Nigeria were highly vulnerable to climate change than those who were young.

About 59.3 % of the surveyed households participate in Farmers Association followed by community-based organizations such as *(Edir, Ekub etc.)* and some households participate in youth union, water resource users association and credit/saving groups. The assistance they receive from these social networks (social safety nets) were during weeding, harvesting, and technical/equipment support and credit services (Appendix Table 4). The result from correlation analysis showed that socioeconomic characteristics such as participation and help received from social networks, ownership of cell phone, ownership of radio, access to input and output market, low level of education of the household head and information on weather forecast for their locality have high association with climate-related shocks such as soil erosion, erratic rainfall, below average rainfall and drought effect that have happened in the past ten years (Appendix Table 3).

The farmers with less linkage of these socioeconomic characteristic were more vulnerable than farmers that have strong link of social networks. The annual income of the farmers was very low with an average of 5540.38 ETB from subsistence farming and with average of 2215.15 ETB from cash crop (coffee) (Table 3.). This is because the farmers are only dependent on farming activities but do not have additional income generating activities such as off-farm job opportunities. This result was in agreement with that of Derese *et al*. (2010) who reported that farmers in Nile basin were poor in terms of income because the majority of the farmers were subsistence farmers and has limited off-farm job opportunities. The land holding size of the surveyed households, which is one of the socioeconomic characteristics, were varied among the households. 82.2 % of the respondents produced on their own land while 15 % of surveyed household's share (sharing the crop after harvesting) with farmers who own the land and 1.3 % of the surveyed households produced by renting in land from other farmers (Table 3).

Table 3. Asset and income of Coffee farmers' households

ASSET VARIABLES	N	%	Mean	Max	Min
Income from subsistence farming (ETB)			5540.38	16250	1300
Annual income from coffee (ETB)			2215.15	18000	100
Own land and own use	245	82.20%			
Renting land	5	1.30%			
"Pure" Share cropping	40	14.80%			

Source: Owen compilation from household survey Ageyo- setema 2014

All the surveyed households owned their primary residence made up of wood and wood products while the roof material of the 72 % of surveyed households were iron sheet and 28 % were thatch (grass), More than 50 % of the households have radio and cellphone for their information utilization (Appendix Table 4). Access to information and communications infrastructure is arguably important in influencing vulnerability. This is in agreement with the result of Vincent (2004) and Deressa *et al*. (2009) who reported that there are many ways that institutional strength and stability of public infrastructure may govern social vulnerability. Basic facilities such as extension service, primary school and transport were available for all surveyed households even if the distance to transportation is different among the households because of their scattered residence from the main road. More than 50 % of the surveyed households have access to medical center (Health post (*tena kela)* and Health center *(clinic*), access to market and water point, while access to electric and secondary school (37 % of surveyed households), and access to cooperative for agricultural inputs in their localities accounts only 2 % and use of improved coffee variety is very low in the past 10 years (21.7) % as well as 33.8 % currently.

4.2. Vulnerability Aassessment.

Socioeconomic Vulnerability

From the first PCA result indicated that households who had completed high school, have access to weather forecast, uses improved coffee variety and, member in social safety nets (social- networks) were less vulnerable. Households who have small number of dependents (members living in the household), ownership of radio, access to input and output market, ownership to cell phone, high level of education of the household head are less vulnerable. The reason behind is that, this socioeconomic factors have high contribution for vulnerability (Table 4). The low education level in the present result makes the households more vulnerable. This might be due to low skill for planning, experimenting, unlikely to be able to reorganize and little interest to adapt climate shocks and particularly uninterested in change of improved agricultural practices.

Similarly, Norris and Baties (1987) revealed that higher level of education was believed to be associated with access to information on improved technologies and higher productivity. Result from correlation also indicate that socioeconomic variables such as access to weather forecast, members in social-networks, education of the household head and ownership of cellphone and radio have correlation with climatic factors like erratic rainfall effect, below average rainfall effect soil erosion, etc. (Appendix Table 3) . Evidence from various sources indicates that there is a positive relationship between the education level of the head of the household and the adoption of improved technologies and adaptation to climate change (Lin 1991; Maddison 2006; Anley *et al*., 2007; Deressa *et al*. 2010).

Households with large families forced to divert part of the labor force to off-farm activities in an attempt to earn income in order to make ease the consumption of pressure imposed by a large family (Yirga 2007). Households with a larger pool of labor are more likely to adopt agricultural technology and use it more intensively (Croppenstedt *et al*., 2003). The present finding disagree with the above two findings as the household size was higher the level of vulnerability is also high. This is because the contribution of the family members (households) was very low in both on farm and off farm activities. The result from the socioeconomic vulnerability analysis showed that household's with well-connected household characteristics and public infrastructure was less vulnerable because of the ability to be able to deal with a hazard effectively and reduce the vulnerability. Such a society could be said to have low social vulnerability Handmer *et al*. (1999) reported similar result.

Table 4. Socioeconomic variables of climate change vulnerability

	Vulnerability variables	Factor score
	Household head completed Secondary School	0.789
	Access to Medical center	0.586
	Access to Electricity	0.517
	Group of social safety net in which the HH are member	-0.41
	Age of the HH head	0.724
	Owner of Cellphone	0.58
	Roof material for the main dwelling unit	0.598
	Use of improved Coffee variety currently	-0.426
Adaptive capacity	Access to Market	0.531
	Help received from group safety net group	0.457
	Access to weather forecasts in local area	-0.45
	Use of improved Coffee variety previous(10 years ago)	0.586
	Main Source of Household Income	0.66
	Household size (members currently living in the household)	-0.427
	Sex of the respondent	0.539
	Owner ship of radio	0.410
	Eigen value	**1.019**
	Percentage variance	**5.993**
	Cumulative variance	**66.79**

Source: computed from household PCA result of household survey Ageyo- setema 2014/15

4.3. Past climate shock events due to climate change and variability

In the study areas the major past climate-related event that had been happened and significantly affect the households showed were drought, erratic rainfall pattern,(Figure 3) animal disease, coffee diseases, dry spells and so on (Table 5).This shocks affect the socioeconomic, livelihood of the farmers significantly. This result is in agreement with the finding of Salinger *et al*. (1989) for decrease/drying of rivers, Abdelmagid, and Adil (2014) for drought, erratic rainfall and pest, disease and weed infestation, which was reported for Guinea and Sudan Savanna.

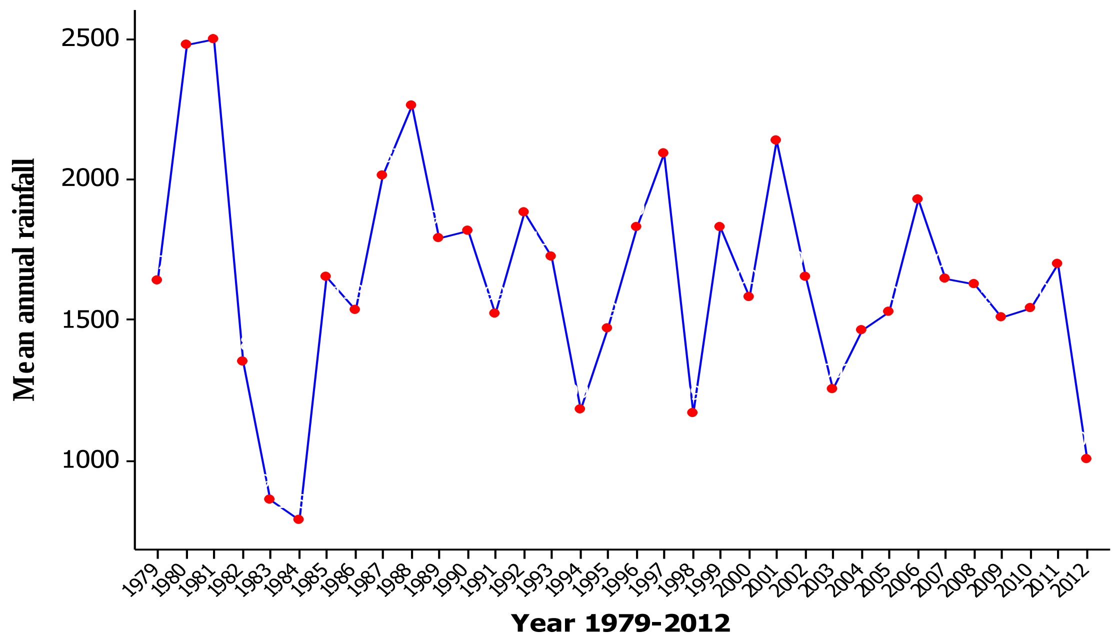
The outcome of the events were decline in crop yield, food shortage, death of animals and health problems on people, loss of asset and income, the more vulnerable groups to this shocks were farmers who have small socioeconomic activities, and also females, aged people and children. The top three impacts that significantly affect the livelihood of the coffee farmers were erratic rainfall, coffee disease and animal disease respectively. Similar results were reported by Deressa *et al*.(2009) ; Zenebe *et al*. (2011) and Joshua *et al*. (2013) for the outcome of disaster events which are decline in crop yield, food shortage, death of animals and health problems on people, for different parts of Ethiopia and Uganda.

Table 5. Past climate shocks that affect households in Ageyo – Setema

Year	Past disasters(climate shocks
1983	Drought shock
1997	Drought shock
2000	Drought shock
2002	Erratic rainfall pattern
2001	Animal disease
2006/7	Below average temperature
2008	Animal disease
2008-2014	Coffee disease

2008-2014	Drying of revers/streams
2001-2014	Wildlife damage on crop and asset
2001-2010	Soil erosion
2013/14	Above average rainfall

Source: Owen compilation from focus group discussion Ageyo- setema 2014/15



Data source : Jimma Meteorology Station (2014)

Figure 3. Rainfall variability for the research transects from year 1979 to 2012.

4.4. Climate-Related and Non-Climatic-related Shocks

The 300 surveyed households mentioned that they had encountered many environmental and climate-related shocks. Result from chi-square shows that major climatic shocks that had happened and had significant effect on households were coffee disease 88 %, drought 43 %, and insect pest attack on crops before harvest 33.4% and erratic rainfall pattern 79 % (Table

6). The non-climatic shocks were wildlife damage on crop 79 % and crop loss during storage35.6 % (Table 7). The climate-related shocks has outcome are outcome of coffee disease, outcome of drought and outcome of erratic rainfall pattern which significantly affect the households (Table 8). From chi-square result the shocks highly contributed for crop yield decline followed by loss of income, shortage of food, change in the onset and cessation of the growing season and decline in livestock productivity, which increased households' vulnerability to climate change This finding is in agreement with Gutu *et al*. (2012) who reported that climate change induced shocks seriously affects the crop and livestock production system. Moreover, Agrawala *et al*. (2003) found that climate change have strongly negative impacts on main food crop whereas positive impacts on significant cash crops (coffee). However, the present finding disagree with those findings because the climate change induced shock had negative impact on both staple and cash crop (coffee) in the study area. (Table 8) This could be due to difference in agro-ecology or management practices. The result also indicated that coffee pest and disease (coffee berry disease, coffee wilt and coffee leaf rust) also plant disease such as head smut of teff (*wag*), maize cob rot and wilt disease on horticultural crops such as papers, pest attack on crop before harvest such as maize, stem borer, cut worm increased from time to time due to climate variability. This agrees with the finding of Volney and Fleming (2000) and Ghini *et al*.(2008) who reported that increase of pest and disease is supposed to be a consequence of increasing temperature and the distribution of nematodes and leaf miner is due to climate change impact.

The present study also revealed that the frequency of drought and dry spells has been increased from time to time. Other shocks which are non-climatic shocks happened in the past ten years mainly includes, crop damage during storage and wildlife (monkey, bush pig and boar) damage on crop (Table 9). Decline in crop yield and loss of income/asset this leads to decline in crop yield, food insecurity and vulnerability (World Bank, 2003; Deressa et *al*., 2009). Moreover, climate-related shocks had similar outcome with that of climate extreme shocks which results to food insecurity and vulnerability.

Table 6.Climate-related shocks in the study area

Climate -related shocks	Setema		Diffo		Ageyo		Total	X^2	P-value
	(n)	%	(n)	%	(n)	%			
Coffee disease	72	88.8	118	90.07	73	84.88	88.25	82.186	0.008**
Drought shocks	72	18.5	43	54.5	130	50	43.4	20.576	0.002**
Above average rainfall shock	9	12.3	11	6.8	30	12.6	10	2.656	0.265
Below average rainfall shock	56	43.2	46	42.4	137	53.4	45.8	2.696	0.26
Erratic Rain Fall shocks	100	77.7	82	73.4	73	88.5	79	7.232	0.027*
Landslides shocks	3	0.1	0	0.8	3	2.4	1.07	2.281	0.32
Soil Erosion shocks	97	12.1	77	17	237	23.1	17.5	4.557	0.336
Insect Pest Attack on Crop Before Harvest	21	26.25	39	30	99	45.34	33.4	8.028	0.018*
Animal Disease	28	28	34	25.95	23	26.74	28.61	3.399	0.493

Source: computed from chi-square test for household survey Ageyo- setema 2014/15

Table 7.Non-climatic-related shocks in the study area

non-climate-related socks	setema		Diffo		Ageyo		Total	X^2	P-value
	(n)	%	(n)	%	(n)	%			
Crop Loss at Storage	32	39.5	118	36.6	73	33.72	36.57	1.395	0.845
Wild Life Damage to Crop	64	79	103	78.6	66	76.74	78.18	.152	0.927

Table 8.Outcome of climate-related shock in the study area

outcome of climate related shocks	Results of the out come	Setema	Diffo	Ageyo	Total	x^2	P- value
outcome of coffee disease	Decline in crop yield	69.4	68.6	79.4	71.8	62.781	0.006**
outcome Drought	Change in onset and cessation of growing season	33.3	56.9	20	41.6	58.446	0.005**
outcome Above average rainfall	Decline in crop yield	72.9	46.4	65.2	59.7	17.118	0.25
outcome Below average rainfall	Decline in crop yield	60	50	60	56.6	22.070	0.077
outcome Erratic Rain Fall pattern	Decline in crop yield	68.2	42.2	50.6	51.8	30.026	0.037**
outcome of Land slid	Decline of income	7.9	3	1.2	3.7	3.000	0.083
outcome of Soil erosion	Decline in crop yield	100	86.3	83.3	87.7	9.047	0.528
outcome of insect pest shock	Decline in crop yield	90.9	87.17	88.09	88.34	4.061	0.668
Outcome of animal disease shock	Death of livestock	75	85.7	78.2	80.2	6.366	0.383

Source: computed from chi-square result of household survey Ageyo- setema 2014/15

Table 9.Outcome of non-climatic shock in the study area

Outcome of non-climate-related shocks	Results of the out come	Setema	Diffo	Ageyo	Total	X^2	P-value
Outcome of crop loss at storage	Food shortage/insecurity	3.1	2.04	6.6	3.6	79.257	0.049
Outcome of wild life damage to crop	Decline in crop yield	53.1	55.3	83.3	62.6	95.295	0.15

Source: computed from chi-square result of household survey Ageyo- setema 2014/15

4.5. Vulnerability of Coffee Farmers

Components of the indices of adaptive capacity, exposure and sensitivity from PCA gave farmers living in the middle part of the study area had positive value while negative for those of the upper (highland) and the lower (low land) with Eigen value greater than 1 and cumulative variation greater than 63 % were taken from the first principal component analysis which explains the majority of the variation in the data set (Appendix Table 5). Net effect of vulnerability index calculation for agro ecology showed that the vulnerability index is -1.07, 1.28 and -0.92 for Setema, Diffo and Ageyo respectively (Figure 4). and for coffee farmer households indicates that 51% of the coffee farmers were highly vulnerable, 19 % of the coffee farmers were moderatly vulnerable and 30% of the coffee farmers were less vulnerable. Coffee farmers in the high land parts and low land parts of the study area are more vulnerable to the impact of climate change than coffee farmers in the middle altitude. This might be because of the agro-ecology, the farmers' in middle altitudinal zone perceive less shock on their coffee plants as compared to the low land part. This is because in the highland part of the study area the farmers loss almost all of their coffee yield due to coffee berry disease (CBD) and less adapt (cope) the outcome of this shocks, also farmers in the lowland part loss their coffee yield and income from coffee due to coffee leaf rust, CBD and many insect pests while the yield reduction due to different disease and pests is low for the middle part of the study area. In addition, the farmers' social network and information utilization is better in the middle part of the study area this might be due to the strong link of the farmers to the village administration ("*tokoshane")* as compared with the highland and lowland parts. Because of these factors, coffee farmers living in the middle part of the study area showed less vulnerable to the impact of climate change. The result for highland part agrees with the finding of Deressa *et al*. (2009 and Gutu et *al*. (2012). Setema was more vulnerable followed by Ageyo and Diffo. From the first PCA the factor score and normalized value the vulnerability indices show that Setema has medium exposure, high sensitivity and low adaptive capacity and Ageyo also have high exposure, sensitivity and low adaptive capacity comparatively while Diffo has high exposure, medium sensitivity and very high adaptive capacity (Table 10).

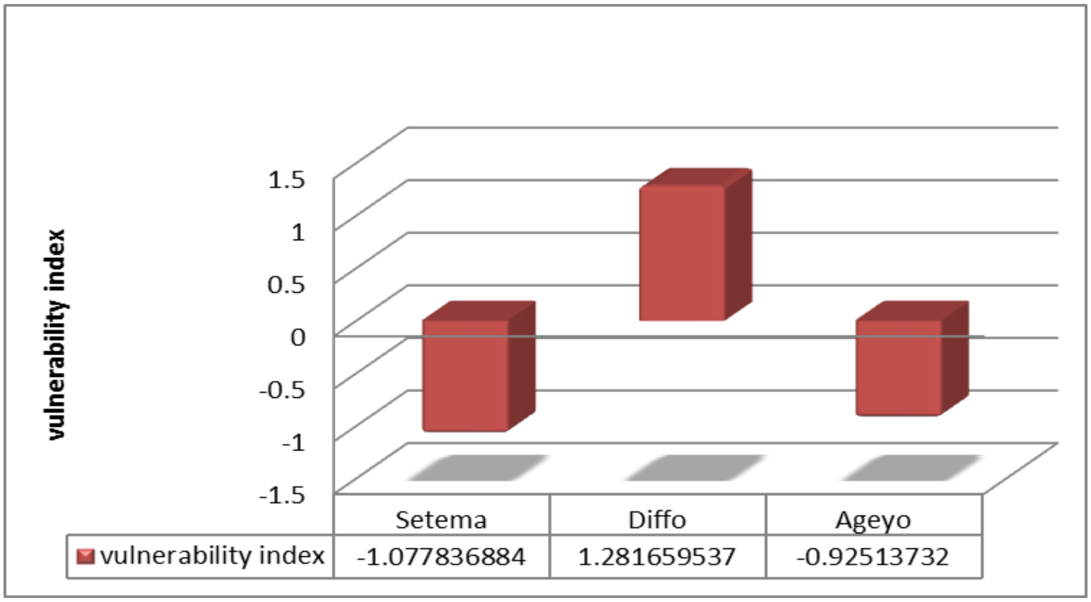
Adaptive capacities such as social safety nets (social networks), farmers association credit and saving, community based organizations, highest level of education for head of the household which helps to plan, manage and adapt to shocks, use of improved coffee varieties both previously and currently, information on weather forecast ware higher for Diffo. This is due to their access and ownership of radio, cellphone and the social network is better when compared to that of Setema and Ageyo. Even if the exposure for Setema and Ageyo is higher and sensitivity is lesser than that of Diffo because of their low adaptive capacity the farmers become more vulnerable. Indeed, vulnerability is highly influenced by the degree of development and socioeconomic status of a particular group or community. The right of individuals to capital assets including financial, human, natural, physical, and social capitals could affect their ability to cope with the impacts of climate change.The present study agree with Smith and Lenhart. (1996); Gbetibouo *et al*. (2010); Philip *et al*. (2012) and Notenbaert *et al*. (2013) who reported that countries with well-developed social institutions are considered to have a greater adaptive capacity than those with less institutional arrangements. Also O'Brien *et al*. (2004) reported that areas with better infrastructure are expected to have a higher capacity to adapt to climate change.

Table 10.Vulnerability indices for the study area

	vulnerability variables	Indices for Setema	Indices for Diffo	indices for Ageyo
Adaptive capacity	Access to Secondary School	0.45954	0.4743	0
	Access to Medical center	0.508	0.686	0
	Access to Electricity	0.33189	0.46	0.19311
	Group of social safety net in which the HH are member	0.352	0.404	-0.04932
	Age of the HH head	0	0	0
	Highest level of education of the HH head	-0.659	0.611	0.063648
	Access to Cellphone	0	0.502	0.0771

	Roof material for the main dwelling unit	0	-0.476	0.06948
	Use of improved Coffee variety currently	0	0.17745	0
	Access to Market	0.521	-0.6	-0.1127
	help received from group safety net group	0	0.467	0.07245
	Access to weather forecasts in local area	0	0.627	0
	Use of improved Coffee variety previous	0.52164	-0.40725	-0.121
	Main Source of Household Income	-0.13925	0	0.593
	Household size (currently living in the household)	0.1265	0.559	-0.0996
	Sex of the respondent	-0.39494	0.64	0.26676
	Access to Radio	0	0.48174	0
Exposure	Animal Disease	0.31447	0.479	0
	Crop Loss During Storage	0.084937	0.663	0
	Insect Pest Attack on Crop Before Harvest	0	0.565	0.026414
	Plant Disease	0	0.08505	-0.01438
	Below average rainfall shock	0	0.549	0.2705
	Erratic Rainfall shock	0	0.637	0.25092
	Drought shock	0	0.536	0.003843
	Wildlife Damage to Crop	0	0.47436	0.0272384
	Loss of top soil (Soil Erosion)	0	-0.677	0.44405
Sensitivity	effect of Erratic Rainfall pattern	0.04977	0.544	0
	effect of plant disease	0	-0.66	0.174636
	effect of crop loss during storage	-0.533	-0.22725	0

Source: computed PCA from result of household survey Ageyo- setema 2014/15

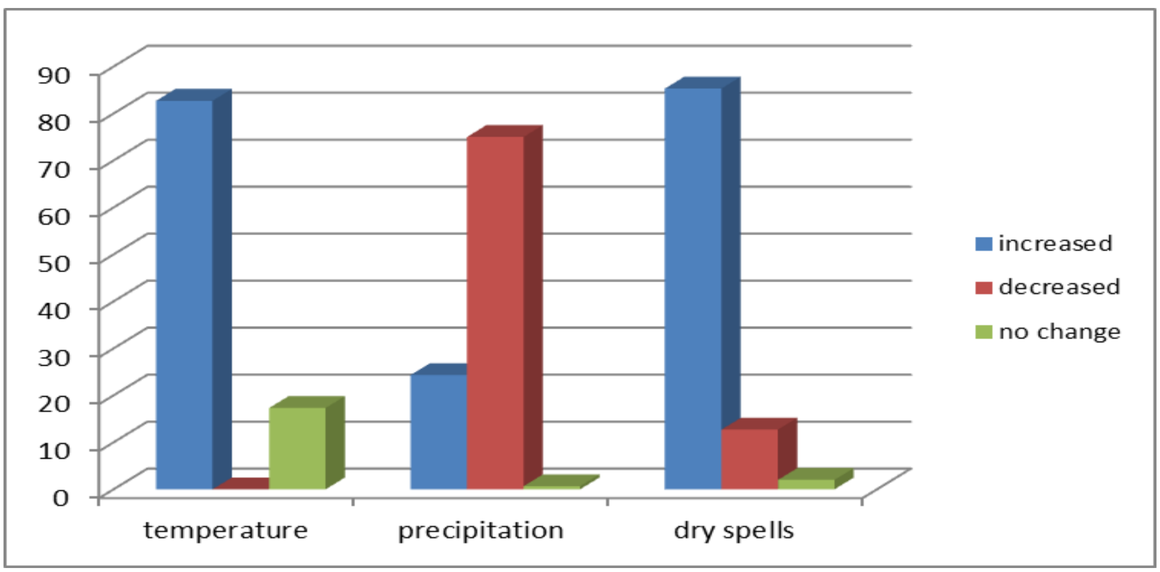


Source: computed from PCA result of household survey Ageyo- Setema 2014/15

Figure 4. Vulnerability index of Setema, Diffo and Ageyo

4.6. Farmers' perception on climate change

Most of the farmers mentioned that there is climate change in their perception during the past 20 years. About 82 % of them mentioned the temperature is increasing from time to time whereas 17.3 % mentioned no change. The surveyed households also perceived changes in precipitation 75 % decreased, 24.3 % increased and 0.6 % no change (Figure 5). The result also indicate that there was a change in frequency of dry spells, 85 % of the surveyed households mentioned an increase in frequency of dry spell where as 12 % of them mentioned the frequency of dry spell in the area is decreased (Figure 5). The present result has similarly outcome with that of Abdelmagid and Adil (2014) results such as soil erosion, increasingly erratic rainfall patterns, and uncertainties in the onset of farming season. The present study also found that farmers' perception on climate change helped them to change and improve their farming practices. This result agrees with that of who reported that the awareness of climate problems and the potential benefits of taking action is important determinant of adoption of agricultural technologies. The result from coffee farmers perception found that the upper part (highland part) of the study area (which had not been suitable for coffee production become suitable. The farmers also reported that in the highland area they started to grow maize crop as the maturity time shorten from 5-6 months before 8 years to 3-4 months due to the increased temperature. This result is in agreement with Volney and Fleming (2000) and Darnhofer *et al*. (2010) who reported about changes in agricultural practices, such as new practices, changes in planting date and climate technology. Coffee farmers' perception and awareness on climate change make them to take action to cope with the changes of climate. The present study found that the actions taken to cope (adapt) for Coffee plant to the climate changes was change in planting date, change in crop variety and change in crop type (Table 9). The result is similar with the finding of Bradshaw *et al*. (2004); Maddison (2006), Hassan and Nhemachena (2007); Kurukulasuriya and Mendelsohn (2006); Hassan and Nhemachena(2008) and Deressa *et al*.(2010) who reported that farmers perceive and later adapt to impacts of a changing climate. Coping strategies to protect farmers against climate-related hazards included planting early and digging drainage channels. Other strategies included planting early-maturing varieties, high-yielding varieties, drought-tolerant varieties, disease- and/or pest-resistant varieties.



Source: Owen compilation from household survey Ageyo- setema 2014/15

Figure 5 Climate change in Farmers' perception during the past 20 years

Table 11. Action taken by Coffee farmers for climate change in the study area

		n	%
Action taken	Change in planting dates	187	95.40
	Change in crop variety	6	3.10
	Did nothing	3	1.50

Source: Owen compilation from household survey Ageyo- setema 2014/15

5. SUMMARY AND CONCLUSION

In this study a total of 300 coffee farmer households were surveyed from Setema, Diffo and Ageyo kebeles and focus group discussion was conducted on 60 farmers 2013/2014 with the objectives of to analyze vulnerability, perception and past disaster events of coffee farmers to the impact of climate change in Ageyo-Setema area of Jimma zone, southwestern Ethiopia .

The socioeconomic vulnerability of households was analyzed for both socio economic and biophysical characteristics of households. The method of principal component analysis (PCA) was used to assign weights to identify which socioeconomic variable make the households more vulnerable to socioeconomic vulnerability. The kebele level household vulnerability to the impact of climate change analyses was based on the integrated vulnerability assessment approach using vulnerability indicators. The vulnerability indicators include different socioeconomic and biophysical attributes of the Kebeles.

The household level of vulnerability analysis result showed that the erratic rainfall patterns (79 %), diseases and pest attack on coffee (88 %)t, drought (47 %), below average rainfall (42 %) and soil erosion (17 %) in the past 10 years were the climatic related shocks in the study area. These shocks results in change in the onset and cessation of the growing season, decline in crop yield, loss of income and asset. The result from the first principal component analysis for socioeconomic vulnerability indicates that variables such as access to information on weather forecast, use of improved coffee variety, membership in social safety nets (social net-works), household size, and owner ship of radio, access to input and output market, owner ship of cell phone, level of education of the household head had more weight. Household with small proportion of these variables were more vulnerable to the socioeconomic and adaptive capacity of the vulnerability.

The result form kebele level (altitudinal gradient) analysis shows that the upper part of the study area which represents the highland part of the study area is more vulnerable to the impact of climate change followed by Ageyo which is the lowland part of the study area, while Diffo which represent the midland of the study area is less vulnerable to the impact of climate change. Even if the exposure for Diffo is comparable with that of Setema and Ageyo, due to high level of adaptive capacity /socioeconomic variables such as social safety nets (social net-works) member in farmer associations and assistance from the association, level of education of the head of the households, use of improved coffee varieties and access to infrastructures made Diffo kebele less vulnerable

The result from perception of farmers in the study area showed most of the surveyed households reported that they perceive climate change in their localities. Change in temperature were 82% increased, and 17 % no change, and for changes in precipitation was mentioned as 24 % increased, 75 % decreased and 6 % no change where as a change in dry spells is reported as increased and decreased by 85 % and 12 % of the households respectively. Their perception helped them to adapt to the changing climate, the action that the households took as adaptation options to the changing climate were changing the date of planting, changing the variety of crops and crop type.

The other finding of the study on past disaster events in the study area from focus group discussion shows that the major past climate-related event which had been happened is drought, erratic rainfall pattern, animal disease, coffee disease, wildlife damage on crop and drying of rivers and streams. This disaster shocks results decline in crop yield, food shortage, death of animals and human health problems and loss of income /asset. With the out puts of these shocks farmers with low adaptive capacity and socioeconomic activities, females, aged peoples and children's were the most vulnerable groups.

There is a climate change and its' impact in the study area in the past as well as in the present and this impacts are both biophysical and socioeconomic impacts that are affecting the livelihood of smallholder coffee farmer households because most of the farmers in the study area are coffee growers, they use their coffee crop as source of income and livelihood but it becomes affected by changing climate this makes the coffee farmers more vulnerable.

Government policies should strengthen the existing adaptation strategies practiced by farmers' and support the adoption of adaptation technologies that have potential to reduce the damages (impacts) at farm level: such as the use of drought tolerant crop varieties, disease and insect pest tolerant crop (coffee) varieties, use of irrigation, shade trees and resource conservation and management practices. Policies that give information on type of adaptation methods and financial resource to support adaptation should be needed to ease the impacts of climate change.

Government policies and strategies that support the provision of and access on climate and adaptation measures are necessary to better adapt to climate change. Policy interventions that encourage income generation, informal and formal social networks (financialiy or materially) can encourage better information flows and improve adaptive capacity and reduce vulnerability to climate change.

There should be a provision of new technologies agro-ecology based packages. Strengthening of social safety nets (social net-works) and establishment of basic facilities such as early warning systems, education and awareness on availability and utilization of weather forecast and educating the community and providing relevant trainings so as to develop the human capacity able to utilize the existing opportunities and assets are important.

The limitation of this study in agro-ecology based coffee farmers households' vulnerability is analyzed at kebele (household) level using different biophysical and socioeconomic attributes by using integrated approche of vulnerability assesment. Further research should focus on kebele (household) by using differente models such as econometrics model to assess the level of vulnarabilty of households to the impact of climate change.

Further research should be done by relating time series data of coffee yield with socioeconomic characteristics of the farmers along altitudinal gradient in order to identify which socioeconomic characteristics is affected by climate change and affect yield and make the farmer more vulnerable and panel data should be used to yield more sounding result because panel data capture household characteristics before and after shocks.

6. **REFERENCES**

Aandahi, G., and K. O'Brien. 2001. Vulnerability to climate change and economic and economic changes in India agriculture. Paper presented at the biannual conference of the Nordic Association for South Asian Studies. Voss,Norway,20-22 september.

Abdelmagid Ali Elmobarak and AdilMahgoub, 2014.Potentiality of a desert plain soil to irrigation in River Nile State-Sudan: African Journal of Agricultural research 9(24):1820-1920.

Abimbola Opeyemi Longe and Abayomi Samuel Oyekale,2013. Assessment of Climate Change Vulnerability and Adaptation among Smallholder Cocoa Farmers in Osun State, Nigeria Life Science Journal 10(2) http://www.lifesciencesite.com

Adams, R.M.1989.Global climate change and agriculture: an economic perspective. American Journal of Agricultural Economics, 71(5): 1272-1279.

Adger,W. N., Huq, S., Brown, K., Conway, D., and Hulme, M. 2003. Adaptation to climate change in the developing world. Progress in development studies,3(3): 179-195.

Agrawala, S., Moehner, A., Hemp, A., van Aalst, M., Hitz, S., Smith, J. and Mwaipopo, O. U. 2003. Development and climate change in Tanzania: focus on Mount Kilimanjaro. Environment Directorate and Development Cooperation Directorate, Organization for Economic Cooperation and Development (OECD), Paris.

Anley, Y., Bogale, A., and Haile-Gabriel, A. 2007. Adoption decision and use intensity of soil and water conservation measures by smallholder subsistence farmers in Dedo district, Western Ethiopia. Land degradation and development, 18(3), 289-302.

Araya, B., and Asafu-Adjaye, J. 2001. Adoption of Farm-Level Soil Conservation Practices in Eritrea. Indian Journal of Agricultural Economics, 56(2), 239-252.

Battisti, D. S., and Naylor, R. L. 2009. Historical warnings of future food insecurity with unprecedented seasonal heat. Science, 323(5911), 240-244.

Bradshaw, B., Dolan, H., and Smit, B. 2004. Farm-level adaptation to climatic variability and change: crop diversification in the Canadian prairies. Climatic Change, 67(1), 119-141.

Brooks, N., Adger, W.N., 2003. Country level risk indicators from outcome data on climate-related disasters: an exploration of the Emergency Events Database. Norwich: East Anglia, mimeo.

Brooks.N.,Adger,W.N and Kelly P.M.2005. The determinants of vulnerability and adaptive capacity at the national level and the implication for adaptation. Global Environmental change, 15(2):151-163.

Camargo AP 1985. Florescimento e frutificac¸a˜o de cafe´ ara´bica nas diferentes regio˜es cafeeiras do Brasil. Pesqui Agropecu Bras 20: 831–839.

Camargo MB, 2010. The impact of climatic variability and climate change on Arabic coffee crop in Brazil. Bragantia 69: 239–247.

Carter, T.R., Jones, R., Lu, X., Bhadwal, S., Conde, C., Mearns, L., O’Neill, B., Rounsevell, M.and Zurek, M. 2007. “New assessment methods and the characterisation of future conditions”: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the I P CC, Cambridge University Press, Cambridge, pp. 133-71

Christensen, J.H., B. Hewitson, A. Busuioc, A. Chen, X. Gao, I. Held, R. JonesR.K. Koli,W.-T. Kwon, R. Laprise, V.M. Rueda, L.Mearns, C.G.Menéndez, J.Räisänen,A. Rinke,A. Sarr and P.Whetton, 2007: Regional climate projections. Climate Change: The Physical Science

Basis. Cambridge: Climate change: impacts, vulnerabilities and adaptation in developing countries pp8

Cooper, P.J.M., Dimes, J., Rao, K.P.C., Shapiro, B., Shiferaw, B., Twomlow, S., 2008.Coping better with current climatic variability in the rain-fed farming systems of sub-Saharan Africa: an essential first step in adapting to future climate change Agric. Ecosyst. Environ. 126, 24–35.

Cutter, S. L., Boruff, B. J., and Shirley, W. L. 2003. Social vulnerability to environmental hazards*. Social science quarterly, 84(2), 242-261.

Cutter, S. L., Mitchell, J. T., and Scott, M. S. 2000. Revealing the vulnerability of people and places: a case study of Georgetown County, South Carolina. Annals of the Association of American Geographers, 90(4), 713-737.

Darnhofer, I., Bellon, S., Dedieu, B., and Milestad, R. 2010. Adaptiveness to enhance the sustainability of farming systems. A review. Agronomy for sustainable development, 30(3), 545-555.

Davis AP, Gole TW, Baena S, Moat J 2012 The Impact of Climate Change on Indigenous Arabica Coffee (Coffea arabica): Predicting Future Trends and Identifying Priorities. PLos One 7(11): e47981. doi:10.1371/journal.pone.0047981

Deressa T., Claudia Ringler, Rashid M. Hassan, 2009Assessing Household Vulnerability To Climate Change IFPRI Discussion Paper0093

Deressa T., Claudia Ringler, Rashid M. Hassan, 2010. Factors affecting the choices of coping strategies for climate extremes: the case of farmers in the Nile Basin of Ethiopia. Final START, ACCFP Report.

Deressa Temesgen, Rashid M. Hassan and Claudia Ringler,2008. Measuring Ethiopian Farmers' Vulnerability to Climate Change Across Regional States. IFPRI Discussion Paper 00806.

FAOSTAT. 2005,farming sector to climate change and variability: an indicator approach. Natural,. Estimates of agricultural land use (Internet database). Rome, Italy.

Fischer Gunther, Mahendra Shah, Francesco N. Tubiello and Harrij van Velhuizen, 2005. Socioeconomic and climate change impacts on agriculture: an integrated assessment, Trans.R.oc B (360) 2067-2083.

Forner, C. 2006. An introduction to the impacts of climate change and vulnerability of forests. Background document for the South East Asian meeting of the Tropical Forests and Climate Change Adaptation (TroFCCA) project. Bogor, West Java (May 29–30).

Franklin, S., and T. Downing. 2004. Resilience and vulnerability. Poverty and Vulnerability Programme: GECAFS Project. Stockholm Environmental Institute.

Füssel, H. 2007. Vulnerability: A generally applicable conceptual framework for climate change research. Global Environmental Change 17(2): 155–167.

Füssel, H.-M., and R. J. T. Klein. 2006. Climate change vulnerability assessments: An evolution of conceptual thinking. Climatic Change 75(3): 301–329.

Gallopin, G. C. 2003. A Systemic Synthesis of the Relations Between Vulnerability, Hazard, Exposure and Impact, Aimed at Policy Identification. In Handbook for Estimating the Socioeconomic and Environmental Effects of Disasters. Mexico: Economic Commission for Latin American and the Caribbean (ECLAC).

Gbetibouo, G. A., and Ringler, C. 2009. Mapping South African Farming Sector Vulnerability to Climate Change and Variability. A Subnational Assessment. IFPRI

Discussion Paper 00885. Washington, DC: International Food Policy Research Institute (IFPRI).

Gbetibouo, G. A., Ringler, C., and Hassan, R. 2010. Vulnerability of the South African farming sector to climate change and variability: an indicator approach. Natural Resources Forum, (34)175-187.

Ghini, R.; Hamada, E. Júnior, M.J.P.; José Antonio Marengo, J.A.; Ribeiro do Valle Gonçalves, R.2008.Risk analysis of climate change on coffee nematodes and leaf miner in Brazil.

Gutu Tesso, Bezabih Emana and Mengistu Ketema,2012. Analysis of vulnerability and resilience to climate change induced shocks in North Shewa, Ethiopia:6, 871-888.

Handmer, J.W., S.Dovers and T.E Downing, 1999. "Societal Vulnerability to Climate assessments: the Vulnerability Scoping Diagram. Global Environmental Change, 17(34):472485.

Hassan, R., and Nhemachena, C. 2008. Determinants of African farmers' strategies for adapting to climate change:Multinomial choice analysis. African Journal of Agricultural and Resource Economics, 2(1), 83-104.

Hassan,R and Nhemachena C,2007. Micro-level analysis of farmers' adaptation to climate change in southern Africa. IFPRI Discussion Paper No.00714. international Food policy Research Institute, Washington, DC

Hoddinott, J., and A. Quisumbing. 2003. Methods for micro econometric risk and vulnerability assessments. Social Protection Discussion Paper Series No. 0324. Social Protection Unit, Human Development Network. Washington D.C.: World Bank.

Howden, S.M., Soussana, J., Tubiello, F.N., Chhetri, N., Dunlop, M., Meinke, H.,2007. Adapting agriculture to climate change. Proc. Natl. Acad. Sci. 104,19691–19696.

http://www.thecoffeeguide.org/coffee-guide/climate-change-and-the-coffee-industry/the-coffee-sector-and-climate-change/2010.

http://www.wmo.int/pages/publications/.Thecoffeeguide.org, feb. 2010 ,Climate change and the coffee industry.

Intergovernmental Panel on Climate Change (IPCC) 2007: Synthesis Report an Assessment Represents the formally agreed statement of the IPCC concerning key findings and uncertainties contained in the Working Group contributions to the Fourth Assessment Report.

Intergovernmental Panel on Climate Change (IPCC). 2001. Climate change: The scientific basis.

International Coffee Organization (ICO), 2012.TradeStatistics.Available: http://www.ico.org/trade_statistics.asp section 17

Jimma Zone Agricultural Ofice,2013.

Joshua S. Okonya, Katja Syndikus and Jürgen Krosche, 2013. Farmers' Perception of and Coping Strategies to Climate Change: Evidence From Six Agro-Ecological Zones of Uganda: Journal of Agricultural Science,5(8): 1916- 9752.

Kaiser, H. F., 1960. The application of electronic computers to factor analysis. Educational and Psychological Measurement, 20: 141 - 151.

Kaiser,H. M., S. J. Riha, D. S. Wilks, D. G. Rossiter, and R. K. Sampath. 1993. A farm-level analysis of economic and agronomic impacts of gradual warming. American Journal of Agricultural Economics 75: 387–98.

Kelly P. M., and W. N. Adger. 2000. Theory and practice in assessing vulnerability to climate change and facilitation adaptation. Climatic Change 47(4): 925–1352.

Kurukulasuriya, P., and R. Mendelsohn. 2006. A Ricardian analysis of the impact of climate change on African crop land. CEEPA Discussion Paper 8. Centre for Environmental Economics and Policy in Africa. Pretoria, South Africa.

Langyintuo,A S,2005. Maize production system for Zimbabwe :. International Maize and Wheat Improvement center (CIMMYT).Harare, Zimbabwe.

Lankester, A., 2012. Self-perceived roles in life and achieving sustainability on familyfarms in north-eastern Australia. Aust. Geogr. 43, 233–251.

Leichenko, R. M., and K. L. O'Brien. 2001. The dynamics of rural vulnerability to global change: The case of Southern Africa. Mitigation and adaptation strategies for global change7(1): 1–18.

Leutze S., Aklili Y.,Raven-Roberts A.,Young H., Kebede G. and LearningJ. 2003. Risk and Vulnerability in Ethiopia: Learning from the past, Responding to the present, preparing for the future. Report for the U.S Agency for International Development. Addis Ababa, Ethiopia.

Liverman, D.M., 1990. Drought impacts in Mexico: climate, agriculture, technology, and land tenure in Sonora and Puebla. Annals of the Association of American Geographers 80, 49–72.

Luni Piya, Keshav Lall Maharjan and Niraj Prakash Joshi,2012.Vulnerability of rural households to climate change and extremes: Analysis of Chepang households in the Mid-Hills of Nepal.

Maddison, D. 2006. The perception of and adaptation to climate change in Africa. CEEPA Discussion paper No. 10, CEEPA, University of Pretoria, South Africa.

Marshall, N.A., 2010. Understanding social resilience to climate variability in primary enterprises and industries. Global Environ. Ch. 20, 36–43.

Marshall, N.A., 2011. Assessing resource dependency on the rangelands as a measureof climate sensitivity. Soc. Nat. Resour. 24, 1105–1115.

Marshall, N.A., Gordon, I.J., Ash, A.J., 2011. The reluctance of resource-users to adoptseasonal climate forecasts that can enhance their resilience to climate variabil-ity. Clim. Ch. 107: 511529.

Marshall, N.A., Park, S.E., Adger, W.N., Brown, K., Howden, S.M., 2012. Transforma-tional capacity and the influence of place and identity. Environ. Res. Lett. 7,034022.

McCarthy, J.J., Canziani, O.F., Leary, N.A., Dokken, D.J., White, K.S. (Eds.), 2001. Climate Change Impacts, Adaptation.

McMillan, M., Assefa Tigneh, Yohannes Agnofir, Kibre Moges and Amdissa Teshome 2003. Ethiopia Trade and Transformation Challenges. Agriculture and Trade Diagnostic Trade Integration Study. 8(2,) Addis Abeba, Ethiopia.

Mendelsohn, R., A. Dinar and A. Dalfelt, 2000: Climate change impacts on African agriculture. Preliminary analysis prepared for the World Bank, Washington, District of Columbia, and 25 pp.

Mitchell,T and Tanner,T. 2006.Adapting to climate change-challenges and opportunities for the development community. Teddington,UK Institute of Development studies and Tearfund.

Moss, R., A. Brenkert, and E. Malone. 2001. Vulnerability to climate change, a quantitative Approach. http://www.ntis.gov.html.

Nelson, D.R., Adger, W.N., Brown, K., 2007. Adaptation to environmental change:contributions of a resilience framework. Ann. Rev. Environ. Resour. 32, 395–419.

Nelson, R., Kokic, P., Crimp, S., Meinke H. and Howden, S.M. 2010. The vulnerability of Australian rural communities to climate variability and change: Part I - Conceptualising and measuring vulnerability, Environmental Science and Policy, 13: 8–17.

NMS (National Meterological Services). 2007. Climate Change National Adaptation Program of Action (NAPA) of Ethiopia. NMS,Addis Ababa.

NMSA (National Meterological Services Agency). 2001. Initial National Communication of Ethiopia to the United Nations Framework Convention on Climate Change (UNFCCC).NMSA,Addis Ababa.

Norris,E.and Baties,S.,1987. Virginia farmers soil conservation decisions:an application of tobit analysis,southern Journal of Agricultural Economics,19(1):89-97.

Notenbaert, A, SN Karanja, M Herrero, M Felisberto, and S Moyo. 2013. Derivation of a household-level vulnerability index for empirically testing measures of adaptive capacity and vulnerability. Regional Environmental Change 13:459–470.

Nyong A.O., Adepetu, A.A, Ihemegbulem, V.C.and Dabi D. 2003. Vulnerability and Adaptive capacity of rural population in the Sahel to climate change and climate variability, Acase study of semi-arid northern Nigeria. Paper presented at the EMF Snowmass Workshop Climate change Impacts and Integrated Assessment.

O'Brien ,K,Leichenko,R.,Kelkar,U.,Venema,H.,Aandahl,G and Tompkins,H.2004. Mapping vulnerability to multiple stressors: Climate change and globalization in India.Global Environmental change,14(4):303-313.

Olsson, P., Folke, C., Hughes, T.P.,2008. Navigating the transition to ecosystem-basedmanagement of the Great Barrier Reef, Australia. Proc. Natl. Acad. Sci. USA105,948-949

Panagiotis Karfakis Leslie Lipper and Mark Smulders,2012. The assessment of the socio-economic impacts of climate change at household level and policy implications. Building Resilience for Adaptation to Climate Change in the Agriculture Sector Agricultural Development Economics Division, FAO, Rome pp.36

Parry, M.L., Canziani, O.F., PalutikoF, J.P., Vander linden P.J. And hanson, C.E. Polsky, C., and W. E. Esterling. 2001. Adaptation to climate variability and change in the US Great Plains: A multi-scale analysis of Ricardian climate sensitivities. Agriculture, Ecosystem and Environment 85(3): 133–144.

Philip Antwi-Agyei , Evan D.G. Fraser , Andrew J. Dougill , Lindsay C. Stringer , Elisabeth Simelton;2012.Mapping the vulnerability of crop production to drought in Ghana using rainfall, yield and socioeconomic dataApplied Geography (32) 324-334

Polsky, C.Neff, R. and Yarnall, B. 2007. Building comparable global change vulnerability assessments: the vulnerability scoping diagram‖, Global Environmental Change, 17: 472–485.

Rachel Slater, Leo Peskett, Eva Ludi and David Brown, 2007. Overseas Development Institute Climate change, agricultural policy and poverty reduction. Natural Resource Perspectives 109 Security And Its Adaptation Programs In Indonesia. J. ISSAAS Vol. 17, No. 1:40-51.

Salinger, M.J. 1989. The effects of greenhouse gas warming on forestry and agriculture'. Draft report for WMO Commission of Agrometeorology, 20.

Skoufias, E. and Vinha, K. 2012. Climate variability and child height in rural Mexico. Economics and Human Biology, 10: 54–73.
Smit, B. and Wandel, J. 2006. “Adaptation, adaptive capacity and vulnerability”.

Smith J. and Lenhart,S.S 1996. Climate change adaptation policy options. Climate Research 6(2)2:193-201.

Stevens, J., 1986. Applied multivariate statistics for the social sciences. Hillsdale, NJ: Lawrence Erlbaum Associates.

Supin Wongbusarakum and Christy Loper ;2011.Indicators to assess community-level social the differences in their levels of vulnerability to climate change.

Timmermann,1981.Vulnerability, Resilience and the Collapse of Society. Number 1 in Environmental Monograph. Institute for Environmental Studies, University of Toronto, Toronto, Canada.

Turner II., B.L., Kasperson, R.E., Matson, P.A., McCarthy, J.J., Corell, R.W., Christensen, L., Eckley, N., Kasperson, J.X., Luers, A., Martello, M.L., Polsky, C., Pulsipher, A., Schiller, A., 2003. A framework for vulnerability analysis in sustainability science. Proceedings of the National Academy of Sciences US 100, 8074–8079.

Vincent Katharine, 2004. “Creating an Index of Social Vulnerability to Climate Change for Africa Tyndall,” Centre for Climate change Research Working Paper 56.

Vincent, K. 2004. Creating an index of social vulnerability to climate change for Africa. Technical Report 56. Norwich, U.K.: Tyndall Centre for Climate Change Research, University of East Anglia vulnerability to multiple stressors: Climate change and globalization in India.

Volney, W.J.A., Fleming, R.A., 2000. Climate change and impacts of boreal forestinsects. Agric. Ecosyst. Environ. 82, 283–294.

Vyas ,Sand Kumaranayake L,2006. Constarcting socioeconomic status indices:How to use principal component analysis. Health policy and planning ,21 (6):459-468.

Watson, R. T., Noble, I. R., Bolin, B., Ravindranath, N. H. and Verardo, D. J. 2000. Land use, land-use change, and forestry. Special report of the intergovernmental panel on climate change. Cambridge, UK: Cambridge University Press.

World Bank,2003. Ethipian : Risk and Vulnerability Assessment. Draft Report.

Yamin, F., A. Rahman, and S. Huq. 2005. Vulnerability, adaptation and climate disasters: A conceptual overview. IDS Bulletin 36: 1–14.

Yirga ,C.T.2007.The dynamics of soil degradation and incentives for optimal management in central Highlands of Ethiopia.

Zenebe Gebre egziabher and Alemu Mekonnen,2011.Climate Change and the Ethiopian Economy A computable General Equilibrium Analysis: Environment for Development: Discussion paper Series EfD DP 11-09.

7. APPENDIX

Appendix Table 1 List of Questionnaires for household survey

CLIMATE CHANGE IMPACTS ON ECOSYSTEM SERVICES AND FOOD SECURITY IN EASTERN AFRICA (CHIESA) HOUSEHOLD QUESTIONNAIRE FOR ASSESSMENT OF HOUSEHOLD VULNERABILITY AND RISK

We are researchers from the CHIESA Project which deals with research on the impacts of climate change on smallholder farmers and the formulation of suitable climate change adaptation strategies to help in reducing the impact of climate change on agriculture. The information you provide will be used solely for research purposes and will be treated with utmost confidentiality.

Name of the Interviewer ____________________________ Date: (DD/MM/YYYY) ________________

Region ____

District ____

Village ____

Location of Household in GPS Coordinates

Latitude (N/S) ______________________________________

Longitude (E/W) ___________________________________

Elevation (m.a.s.l) __________________________________

Indicate time in 24 hour system

Start of Interview (HRS/MIN)_____________________________________

End of Interview (HRS/MIN) _____________________________________

A. DEMOGRAPHIC PROFILE

	CODE	RESPONSE
A1. Name of the Respondent	*(Mark N/D if the information is not available)*	

(Optional)		
A2. Address		
A3. Mobile Phone Number		
A4. Age		
A5. Gender	1. Male 2. Female	
A6. Marital Status	1. Never Married 2. Married and living together 3. Married but not living together 4. Married to more than one spouse 5. Widowed 6. Divorced	
A7. Ethnicity (Optional)	(*Mark N/R if there is no response)*	
A8. Religion (Optional)		
A9. Occupation		
A10. Respondent's Relationship with household head	1. Household head 2. Mother 3. Father 4. Husband 5. Wife 6. Child 7. Grandchild 8. Other Relative (Specify)	
A11. Head of Household (indicate male/female/child headed)	1. Adult Male Headed 2. Adult Female Headed 3. Boy Child Headed (< 18 years) 4. Girl Child Headed (< 18 years)	
A12. Respondent's Highest level of education	1. Primary 2. Secondary/High School 3. Tertiary / College(Diploma) 4. University (Specify; Undergraduate, Graduate, PhD) 5. Technical (e.g. Tailoring, Carpentry etc.) 6. Other (Specialties) 7. No formal Education	
A13. Duration of residence in Jimma Highlands/Mt. Kilimanjaro/Taita Hills *(Indicate area clearly)*	1. Not a resident (Indicate where from) 2. <1 year 3. 1 year – 5 years 4. 5.1 years – 10 years 5. 10.1 years – 15 years 6. 15.1 years – 20 years 7. 20.1 years – 25 years 8. 25.1 years – 30 years 9. >30 years	
A14. Main Source of Household Income (Indicate only one) ***(*From Code 3-6 indicates income***	1. Subsistence Farming 2. Dairy farming 3. Ranching (Beef farming)	

earned outside of the respondent's own farm)	4. Goat/sheep rearing 5. Cash Crop Farming 6. Short Term Agricultural Wage Labour (<3 Months) 7. Short Term Non-Agricultural Wage Labour (<3 Months) 8. Permanent/ Salaried Agricultural Related Employment 9. Permanent/Salaried Non-Agricultural Related Employment 10. Business (Specify) 11. Remittances (Indicate Source) 12. Pension 13. Government Welfare 14. Other(Specify)	
A15. Other Sources of Household Income (Specify)		
A16. Household size (members currently living in the household)		
A17. Number of dependents (*Count only those dependents currently living in the household but not contributing to the household income in cash or in kind)*	1. 1-3 2. 4-6 3. 7 and above 4. None	

B. DEPENDANTS IN THE HOUSEHOLD

B1. Member	**B2. Age**	**B3. Marital Status**	**B4. Level of Education**

Inform the respondent that the succeeding questions address only the other household members who contribute to the household income

C. MEMBERS CONTRIBUTING TO HOUSEHOLD INCOME

C1. Member 1. Head of	C2. Age	C3. Occupation 1. Smallholder Farmer	C4. Contribution to the household (In terms of Days per Week)

Household 2. Spouse(s) 3. Son 4. Daughter 5. Granddaughter 6. Grandson 7. Grandmother 8. Grandfather 9. Other (Specify) (*if more than one member is contributing, indicate them ALL)*		2. Casual Farm Labourer 3. Self employed 4. Business and Retail/Trader 5. Artisan/Mechanic/Factory Worker/Mason 6. Health Worker (Private/Public) 7. Teacher(Private/Public) 8. Government Employee 9. Parasternal Employee 10. Transport Sector 11. Other (Specify)	C4.1 On Farm Contribution	C4.2 Off Farm Contribution

D. SOCIAL SAFETY NETS

D1. Group	D2. Member (Use codes in C1 of preceding table)	D3. Duration of Membership (*In case of multiple membership indicate the earliest year joined*)	D4. Type of help received from group 1. Loan 2. Credit 3. Livestock/Poultry 4. Transportation Support 5. Marketing of Produce 6. Technical/Equipment Support 7. Seeds 8. Tree Saplings (Agro-forestry) 9. Food aid 10. Land preparation 11. Harvesting 12. Weeding 13. Buying inputs 14. Building and maintenance of terraces 15. Other (Specify)
1. Farmers' Association 2. Youth union 3. Women's union 4. Political group 5. Religious group 6. Credit /Saving group 7. Community Based Organization 8. Water Resource Users Association 9. Staff Association 10. Other (Specify)			

E. HOUSEHOLD ASSETS

E1. Type of Asset (Owned by the Household)	E2. 1:Yes; 2: No	E3. How many?	E4. Who owns these assets? From C1 (member id)
1. Primary residence a. Permanent b. Semi-permanent c. Temporary			
2. Business building			
3. Solar panel			
4. Toilet (pit)			
5. Toilet (modern flush)			
6. Car			
7. Motorcycle			
8. Refrigerator			
9. Television			
10. Radio			
11. Cell phone			
12. Bicycle			
13. Computer			
14. Hand Cart			
15. Tractor			
16. Other (Specify)			

F. HOUSEHOLD CHARACTERISTICS

F1. Do you own the main dwelling See Codes	F2. Roof material for the main dwelling unit See Codes	F3. Main source of cooking fuel See codes	F4. Main source of lighting See Codes

F1	F2	F3	F4
1. Owned 2. Rented 3. Other (Specify)	1. Thatch 2. Sticks 3. Tin 4. Iron roof sheets 5. Asbestos 6. Tiles 7. Other (Specify)	1. Firewood from own woodlot 2. Firewood from neighbors' woodlot 3. Firewood bought from the market 4. Firewood from the gazette forest 5. Gas (LPG) 6. Electricity 7. Animal Dung 8. Biogas 9. Farm residue	1. Electricity 2. Candle 3. Lanterns 4. Firewood 5. Solar Panel 6. Generator 7. Biogas 8. Other (Specify)

10. Other (Specify)

G. DOMESTIC WATER USE

G1. Sources of domestic water **key**	G2. Distance to source ***km***	G3. Time to Source	G4. Seasonal Use ***key***	G5. How do you consider quality ***key***	G6. Used for ***key***	G7. Payment for use? ***1=Yes, 2=No***	G8. If yes, how much? (*in local currency)*	
							Amt/month	***Amt/liter***

G1. Source of Rain Water
1. Rooftop rainwater
2. Borehole
3. Spring
4. River
5. Dam
6. Water Pan
7. Lake
8. Stream
9. Piped water at source
10. Piped water into dwelling
11. Irrigation canal
12. Water vendor
13. Other (Specify)

G3. Key for Time to source
1. <30 min
2. 30-60 min
3. > 2 hrs

G4- Key for seasonal use:
1. Rainy season
2. Dry season
3. All year

G5 – Key for water quality:
1. very good
2. good
3. fair
4. poor
5. very poor

Key for G6- used for:
1. Drinking
2. Livestock watering
3. Washing
4. Cleaning
5. All household needs
6. Other (specify _________)

H. ACCESS TO BASIC FACILITIES

H1. Type of Facility	H2. Do you currently have access? (1: Yes; 2: No)	H3. If no, why? ***(key)***	H4. If yes, distance from the household (km)	H5. Did you have access 10 years ago? (1: Yes; 2: No)
Electricity (*ask if electricity is available in the h/hold)*				
Telephone (land line)				
Mobile Phone				
Primary School				

Secondary School				
Medical center				
Market				
Grocery/Hardware Store/Agrovet				
Transport (Bus, Motorcycle, Taxi, Tuk Tuk (Bajaj, Animal Powered Transport)				
Water Point				
Extension Services				

Key for H3 If no access, why?

1. Government did not provide
2. Financial constraints
3. Not available
4. Political instability
5. Insecurity
6. Cultural belief
7. Religious belief
8. No need
9. Time Distance
10. Terrain
11. Physical Constraint
12. Other, specify___________________

I. AVAILABILITY OF AND ACCESS TO WEATHER FORECAST

I1. Are weather forecasts available for your local area (1. Yes 2.No)			
I2. Does your household have access to weather forecasts (1. Yes 2. No 3. Other (Specify)			
I3. If no, give reasons			
I4. If yes, what type of weather forecast do you have access to 1. Conventional Weather Forecast (Provided by National Meteorological Agent) 2. Traditional Weather Forecast (Provided through local observations) 3. Both			
I5. What is the temporal scale of the weather forecast provided? 1. Daily Forecast 2. Weekly Forecast 3. Monthly Forecast 4. Seasonal Forecast 5. Annual Forecast	I6. Source	I7. Level of Reliability	I8. How information is utilized

<table>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Source of Forecast(I6)
1. Radio
2. Newspaper
3. TV
4. Chiefs’ barazas
5. Government extension agents
6. Traditional forecasters
7. Local elders/religious leaders
8. Friends or neighbors
9. Other (Specify)</td><td colspan="3">For level of reliability of the forecast (I7): 1. Very Reliable, 2. Reliable, 3. Unreliable, 4. Very Unreliable 5. No Answer</td></tr>
<tr><td colspan="3">For utilization of information (I8):
1. For land preparation
2. For seed selection and preparation
3. For fodder collection and storage
4. For planting
5. For pesticide/herbicide application
6. For harvesting
7. For post harvest activities
8. Other (Specify)</td></tr>
</table>

J1. Has your household been impacted/affected by climatic events in the last 10 years? (1. Yes 2. No)						
J2. If yes, which climatic events (climate events that significantly affected household income) have affected your household during the last 10 years?						
J3. Type of event (**key**)	J4. When was the event (year in last 10 years)	J5. What was the outcome of the event? **(key)**	J6. What did you do? - Action? **(key)**	J7. Who took the action? *(member id C1)*	J8. How widespread was the event? **(key)**	J9. Estimate of the amount of loss/gain to the household *(local currency)*

CLIMATE IMPACTS TO THE HOUSEHOLD MODULE

Key-Type of climate event (J3):
1. Drought
2. Above average rainfall
3. Below average rainfall
4. Floods
5. Erratic rainfall patterns
6. Hailstorms
7. Lightning
8. Fire Outbreaks
9. Landslides
10. Strong Winds

Action (J6)
1. Did nothing
2. Assistance from friends/relatives
3. Relied on savings
4. Government food aid
5. Sold land
6. Sold house
7. Sold crops
8. Sold livestock
9. Changed farming practice
10. Bought food

How widespread was the impact (J8)?
1. My household only
2. A few households in the village
3. Most households in the village
4. All households in the village
5. A few households in the region
6. Most households in the region
7. All households in the region

11. Loss of top soil (Soil Erosion) 12. Frost 13. Above average daily temperatures 14. Below average daily temperatures 15. Heat waves 16. Others (specify) **Outcome of climate event (J5)** 1. Decline in crop yield 2. Increase in crop yield 3. Loss of income 4. Gain of new income sources (Specify) 5. Loss of assets 6. Acquisition of new assets 7. Loss of entire crop 8. Death of livestock 9. Decline in livestock production 10. Increase in livestock production 11. Increase in food prices 12. Decrease in food prices 13. Food Shortage 14. Food Surplus 15. Damage to infrastructure (e.g. roads, canals, sewerage) 16. Increase in area under production 17. Increase in the length of growing season 18. Increase in the number of growing seasons 19. Occurrence of conditions suitable for growth of new crops and fruit 20. Change in the onset and cessation of the growing season 21. Others (specify)	11. Reduction in household food consumption 12. Sought off-farm employment 13. Ate different types of food 14. Ate wild plants/fruit/animals 15. Exchange animals for cereals 16. Borrowed from bank 17. Borrowed from private money lenders 18. Borrowed from relatives and friends 19. Household member migrated to other rural area 20. Household member migrated to urban area 21. Participated in Food for Work initiative 22. Kept children out of school 23. Others (specify)

J. EARLY WARNING SYSTEM FOR CLIMATE EXTREMES

K1. Have the incidents of 1. drought/ 2. floods changed in your area? 1. Yes 2. No __________

K1.1 If yes, have they 1. Increased 2. Decreased

K1.2 Give reasons for change
____
____
____
____

K1.3. Did you have access to early warning before the last drought/flood? 1. Yes 2. No ____________________

K1.4. If no to the above question, why? 1. Not available, 2. Non access to media devices 3. Delay in the reception of information 4. Other (Specify)

K1.5. If yes, how did you utilize the information in coping with the drought/flood? ____________________

1. Stocking up on food items
2. Digging trenches
3. Planting drought resistant crops
4. Selection of drought resistant seed/crop varieties
5. Purchase of irrigation equipment
6. Purchase of rooftop rainwater harvesting equipment
7. Moving livestock/poultry to higher ground
8. Stocking up on fodder
9. Preparing the furrows
10. Other (Specify)

K2. When was the last drought the household experienced? _______________ (year)	K3. When was the last year the household experienced too much rain/flooding? _____________ (year)
K4. Do you have food reserves for use during the dry season/periods of drought? 1. Yes 2. No	K4.1. Do you have food reserves for use during periods of drought/floods? 1. Yes **2.** No
K5. If yes to the above question, how long do the reserves last you in times of need? 1. 0-2 month 2. 2.1 -4 months 3. 4.1-6 months 4. > 6 months	K5.1 If yes to the above question, how long do the reserves last you in times of need? 1. 0-2 month 2. 2.1 -4 months 3. 4.1-6 months 4. > 6 months
K6. During the last large drought, did you change your farming practice (crop and livestock)? _______ (1. Yes 2. No)	K7. During the last year with too much rain, did you change your farming practice (crop and livestock)? ________ (1. Yes 2. No)
K8. If no, why did you not change your farming practice (use key) (*For both drought and too much rain section*)	

1. No access to money 2. No access to credit 3. No access to land 4. No access to equipment 5. No access to extension services 6. No inputs (e.g. fertilizer/seeds) 7. Shortage of labor 8. No information on climate change and appropriate adaptations **9.** Other (Specify)	

K9. If you changed the farming practices please answer the following questions							
Drought				**Flooding/Too much rain**			
K10. If yes, what did you do? (key)	K11. If yes, how?	K12. If yes, who? (C1-member id)	K13. Indicate from whom you got information on how to implement the change Key**:** 1. Relative 2. Neighbor 3. Project/NGO 4. Government extension 5. Other (specify)	K14. If yes, what did you do? (key)	K15. If yes, how?	K16. If yes, who? (member id-C1)	K17 Indicate from whom you got information on how to implement the change Key: 1. Relative 2. Neighbor 3. Project/NGO 4. Government extension 5. Other (specify)
1. Change in planting dates 2. Change in crop variety 3. Change in crop type 4. Other (Specify)				1. Change in planting dates 2. Change in crop variety 3. Change in crop type 4. Other (Specify)			

Drought				Flooding/Too much rain			
If yes, what did you do? (key)	**If yes, how?**	**If yes, who? (C1-member id)**	**Indicate from whom you got information on how to implement the change** **Key: 1. Relative 2. Neighbor 3. Project/NGO 4. Government extension 5. Other (specify)**	**If yes, what did you do? (key)**	**If yes, how?**	**If yes, who? (C1-member id)**	**Indicate from whom you got information on how to implement the change** **Key: 1. Relative 2. Neighbor 3. Project/NGO 4. Government extension 5. Other (specify)**
K21. Diversification of crops from staple to: (Yes/No) If yes: 1. Fodder 2. Horticulture 3. Cash crops 4. Drought resistant crops 5. Trees for timber 6. Trees for firewood 7. Other (Specify)				K21.1 Diversification of crops from staple to: (Yes/No) If yes: 1. Fodder 2. Horticulture 3. Cash crops 4. Drought resistant crops 5. Trees for timber 6. Trees for firewood 7. Other (Specify)			
K22. Increase in land size under cultivation (specify unit of measurement)				K22.1 Increase in land size under cultivation (specify unit of measurement)			
K23. Decrease in land size under cultivation (Specify unit of measurement)				K23.1 Decrease in land size under cultivation (Specify unit of measurement			
K24. Change in fertilizer application (Yes/No) If yes:				K24.1 Change in fertilizer application (Yes/No) If yes:			

1. Manure 2. Compost 3. Crop residue 4. Commercial fertilizer 5. Other (Specify)				6. Manure 7. Compost 8. Crop residue 9. Commercial fertilizer 10. Other (Specify)			
K25. Use of pesticides (Yes/No) If yes: 1. Organic to Synthetic 2. Synthetic to Organic 3. Mix of synthetic and Organic 4. Other (Specify)				K25.1 Use of pesticides (Yes/No) If yes: 5. Organic to Synthetic 6. Synthetic to Organic 7. Mix of synthetic and Organic 8. Other (Specify)			
K26. Implement soil conservation and water harvesting techniques (Yes/No) (See codes) 1. Terraces 2. Minimum tillage 3. Grass strips 4. Cover crops 5. Diversion ditches 6. Agro forestry 7. Irrigation 8. Zai Pits 9. Other (Specify)				K26.1 Implement soil conservation and water harvesting techniques (Yes/No) (See codes) 1. Terraces 2. Minimum tillage 3. Grass strips 4. Cover crops 5. Diversion ditches 6. Agro forestry 7. Irrigation 8. Zai Pits 9. Other (Specify)			
K27. Indicate change in agriculture and livestock production	**Fill in code from K27 as appropriate**			K27.1 Indicate change in agriculture and livestock production	**Fill in code from K27 as appropriate**		

3. Mixed crop and livestock production 4. Shift from crop to livestock production 5. Shift from livestock to crop production 6. Grow trees with crops (Agro-forestry) 5. Grow trees with pasture 6. Increase in shade trees on the farm 7. Change pattern of animal consumption 8. Increase the number of livestock 9. Shift from crop to fish farming 10. Crop production to fodder production 11. From staple crops to cash crops 12. Decrease the number of livestock (de-stocking) 13. Diversify livestock feeds 14. Change livestock feeds 15. Supplement				1. Mixed crop and livestock production 2. Shift from crop to livestock production 3. Shift from livestock to crop production 4. Grow trees with crops (Agro-forestry) 5. Grow trees with pasture 6. Increase in shade trees on the farm 7. Change pattern of animal consumption 8. Increase the number of livestock 9. Shift from crop to fish farming 10. Crop production to fodder production 11. From staple crops to cash crops 12. Decrease the number of livestock (de-stocking) 13. Diversify livestock feeds 14. Change livestock feeds 15. Supplement			

livestock feeds 16. Change veterinary interventions 17. Change portfolio of animal species 18. Change animal breeds 19. Move animals to another site 20. Seek off farm employment 21. Migrate to another piece of land 22. Set up communal seed banks/food storage facilities 23. Other (Specify)				livestock feeds 16. Change veterinary interventions 17. Change portfolio of animal species 18. Change animal breeds 19. Move animals to another site 20. Seek off farm employment 21. Migrate to another piece of land 22. Set up communal seed banks/food storage facilities 23. Other (specify)			

K. Have any other events/shocks affected your household during the last 10 years? __________________ (1=Yes, 2=No)
(*Has this household been affected by a serious shock—an event that led to a serious reduction in your asset holdings, caused your household income to fall substantially or resulted in a significant reduction in consumption?)*

L1. Type of shock **(See Codes)**	L2. When was the shock (year in last 10 years)	L3. What did the shock result in? **(See Codes)**	L4. Who in the household was most affected by the shock? (C1- member id)	L5. What did you do? - Action? **(See Codes)**	L6. Who took the action? (C1-member id)	L7. How widespread was the shock? **(See Codes)**	L8. Estimate of the amount of loss to the household

Key for preceding question Other types of shocks (L1)

Production shocks

1. Insect pests attack on crops before harvest,
2. Other pest attacks on crops before harvest
3. Crop loss during storage,
4. Plant disease
5. Animal disease,
6. Wildlife damage to crops

Market shocks

7. Large increase in input prices,
8. Large decline in output prices,
9. Inability to sell agricultural products,
10. Inability to sell non agricultural products,
11. Inaccessibility to markets

Political and social shocks

12. Expropriation of land by government,
13. Ethnic violence
14. Forced migration/relocation
15. Discrimination for political reasons,
16. Forced contributions
17. Arbitrary taxation,
18. Discrimination for social reasons,
19. Corruption

Criminal shocks

20. Theft of crops,
21. Theft of livestock;
22. Destruction or theft of tools or inputs for production,

Idiosyncratic (personal) shocks

23. Loss of job by family member;
24. Death of family member (specify)
25. Illness of family member (specify)
26. Separation of family member[s],
27. Dispute with extended family,
28. Dispute with others in village;
29. Imprisonment
30. Other [specify]

Key for L3 - Outcome of shock:

1. Loss of assets,
2. Loss of income,
3. Decline in crop yield;
4. Loss of entire crop
5. Death of livestock;
6. Decline in livestock productivity
7. Food shortage/insecurity
8. Other, [specify________________]

Key for L 5Action

Did nothing,

Sold livestock,

1. Sold crops
2. Sold land/home
3. Sold assets

Borrowed from relatives or friends

Borrowed from bank,

4. Borrowed from private money lenders

Received food aid,

Participated in food for work,

HH head migrated to other rural area,

HH plus others migrated to rural area,

Migrated to urban area,

Sought off-farm employment,

Bought food

Ate less;

5. Ate different foods
6. Kept children home from school

Other [please specify__________]

Key for L7 – How widespread

1: Only my household
2: Some households in the village
3: Most households in the village
4: All households in the village
5: Many households in the region
6: Some households in the region
7: All households in the region

L. LAND TENURE, LAND CHARACTERISTICS, OWNERSHIP AND MANAGEMENT MODULE.

(For this section please ask the respondent to indicate the main parcel of land plus other additional land parcels)

Land characteristics

M1. Area/Size of Parcel (Specify unit of measurement)	M2. Major land use type **(key)**	M3. Major crops (food/cash crop)*(list—one per plot or intercropping)*	M4. Distance from household (km)	M5. Soil type **(See Codes)**	M6. Soil fertility **(See Codes)**	M7. Change in soil quality in the last ten years 1. Improved 2. Same 3. Declined	M8. Reason for change in soil quality (key)	M9. Slope **(See Codes)**	M10. Erosion **(See Codes)**	M11. Who manages plot *(member id)* **(See Codes C1)**

Key for Major land use type (M2):
1. Crop production;
2. Agro-forestry
3. Livestock
4. Grazing land/pasture land
5. Kitchen garden;
6. Farm forestry
7. Fish farming
8. Fodder farming (e.g. solely napier grass on plot)
9. Tree farming
10. Horticulture
11. Other (pls. specify) ________

Key for - Soil type (M5):
1. Black,
2. Brown
3. Grey
4. Red
5. Yellow
6. Murram
7. Sandy
8. Clay
9. Other [pls. specify]________

Key for Soil fertility (M6):
1. Very fertile
2. Moderate
3. Poor

Key for Change in soil quality (M8)
1. Irrigation
2. Improved land use practices
3. Use on inputs

4. Floods
5. Drought
6. Other (specify)

Key for Slope (M9):
1. Flat,
2. Slight incline (up to 20 degrees),
3. Steep

Key for Erosion (M10):
1. No erosion
2. Mild erosion
3. Severe erosion

M. LAND OWNERSHIP AND ITS HOLDING IN THE LAST 12 MONTHS

N1. Land ownership **(key)**	N2. Land title at the parcel level **(key)**	N3. How was the land acquired? **(key)**	N4. If rented, what is the annual rent			N5. Who in this household acquired this parcel? (C1- Member id)	N6. Who has the right to give away this plot? (C1-Member id)
			Cash (*In local currency)*	In kind (units)	In kind *(estimate amount in local currency)*		

N6.1. Have your land holdings increased or decreased in the past 10 years? (1.Increase 2. Decrease 3. No change) ________________________________

N6.1.1 If there has been change, give reason ____

N6.2. What were your total land holdings in 2004? __________________ (*state unit of measurement)*

Key for N1 – Land ownership:
1. Own land and own use,
2. Renting out (cash rent),
3. Renting in
4. "Pure" Sharecropping in,
5. "Pure" Sharecropping out,
6. "Cost-sharing" Sharecropping in
7. "Cost-sharing" Sharecropping out
8. Communal land (traditional ownership),
9. Borrowed land in (Do not pay money or in kind for usage),
10. Borrowed land out (does not receive money or in kind payments for usage)
11. Other (pls. specify___________)

Key for N2- Land title:

1. Government title,
2. Communal tenure [clan, not written],
3. No title
4. Leased in from government
5. Private lease
6. Own title deed

Key for N3- How acquired:

1. Inherited
2. Purchased,
3. Received from the government,
4. Allocated by the community
5. Leased
6. Other [please specify]____________

N7. LAND MANAGEMENT (CROP AND GRAZING LAND)

N7.1 What type of soil and water management practices are you using on crop land? (key)	N7.2 Since when did you start using this practice? (year)	N7.3 What previous practices did you use? (key)	N7.4 Why did your practices change? (key)	N7.5 What management techniques are you using for grazing land? (key)	N7.6 Since when did you start using this practice? (year)	N7.7 What previous practices did you use? (key)	N7.8 Why did your practices change? (key)	N7.9 If using water harvesting, what type? (key)	N7.10 If using irrigation, what type? (key)	N7.11 What source of water do you use for irrigation? (Key)

Keys next page

N7.12. Are you leaving land fallow? ____________________________ (1=Yes 2=No)

N7.13. Do you consider your grazing land to be over grazed? _______________ (1=Yes 2=No 3= Don't know)

N7.14. What do you do with crop residues after harvesting? ____________________________________ (Key)

Key for N7.14

1. Slash and burn
2. Slash and leave it on the surface for livestock to graze on
3. Slash and store as forage for livestock
4. Do nothing and leave the residue as they are until the next season
5. Slash and sell the residue
6. Slash and use as thatch material
7. Slash and leave them lying on the surface until the next season
8. Use as firewood
9. Used for trash line making
10. Slash and use for mulching
11. Other (specify)

Key for N7.1 and N7.3 – Type of soil and water conservation:

1. Nothing
2. Fanya Juu terraces (soil bunds up slope)
3. Fanya Chini (soil bunds down slope) (creates a cut off drain or a retention ditch)
4. Bench terraces
5. Trenches
6. Irrigation
7. Stone bunds
8. Mulching/surface cover
9. Trash line
10. Log line
11. Slash and burn
12. Grass strips
13. Hedge rows (shrubs)
14. Conventional tillage
15. Minimum tillage
16. Infiltration ditches
17. Ridge and furrow
18. Fallowing
19. Improved fallowing
20. Composting
21. Farm yard manure
22. Green manure
23. Fertilizer (inorganic straight)
24. Fertilizer (inorganic compound)
25. Agroforestry
26. Shade trees
27. Cover crops
28. Crop rotation
29. Crop rotation with legumes (nitrogen fixing)
30. Intercropping
31. Small dams
32. Water pans
33. Others, specify______________

Key for N7.5 and N7.7- Grazing land management

1. Enclosure of the land
2. Restriction on livestock numbers (destocking)
3. Maintain large stocks
4. Removal of unwanted bush
5. Periodic resting
6. Open grazing area
7. Zero grazing
8. Cattle routing
9. Common watering points
10. Supplementary fodder production
11. Others, specify__________________

Key for N7.4 and N7.8- Why has your crop land/grazing land practices changed?

1. To increase productivity/yield
2. To increase water holding capacity
3. To increase biological control of pests and diseases
4. To reduce conflict with neighbours
5. To increase soil fertility
6. To reduce erosion
7. Other, specify_____________________

Key for N7.9- Type of water harvesting

1. Roof water harvesting
2. Earth dams
3. Tree crop ditches
4. Ridge and furrow
5. Retention ditches
6. Road water harvesting
7. Catchment tanks
8. Underground tanks
9. Rock catchments
10. Extraction from springs
11. Extraction from rivers
12. Extraction from lakes and reservoirs
13. Sand dams
14. Other, specify_______________________

Key for N7.10 -type of irrigation

1. Flood irrigation
2. Ridge and Furrow irrigation
3. Drip Irrigation
4. Overhead irrigation
5. Watering Can
6. Other (Specify)

Key for N 7.11-Sources of Water for Irrigation

1. Public borehole
2. Private borehole
3. Springs
4. Lakes and reservoirs
5. Dams
6. Water Pans
7. River
8. Rainwater
9. Other (Specify)

N. AGRICULTURE PRODUCTION AND FOOD SECURITY MODULE

O1. Does your household normally undertake crop farming? 1. Yes-Rain-fed 2. Yes-irrigated 3. Yes R&I 4. No	O2. Did your household grow any crops during the last 12 months? 1. Yes 2. No		O3. If no in the previous question, what was the reason (See Codes)	O4. Name all crops that the h/hold farmed in the last 12 months by season and acreage				O5. Expected harvest in the last 12 months		O6. How much did h/hold actually harvest in the last 12 months from parcel planted (See codes)		O7. How much of the harvest was consumed by the household in the last 12 months		O8. How much of the harvest was sold in the last 12 months		O9. What was the total earning from the sales (*in local currency*)	O10. In the last 12 months has the household had to acquire land elsewhere for crop production (If yes, give reason) 1. Yes 2. No
	Long rains (LR)	Short rains (SR)		LR		SR		LR	SR	LR	SR	LR	SR	LR	SR	Amt	
				Crop	Acre age	Crop	Acre age	Qty	Qty	Qty	Qty	Qty	Qty	Qty	Qty		

Key for not growing crops (O3)
1. No seeds
2. Delay in seed reception
3. Poor seed quality
4. Inaccessibility to land
5. Insufficient land acreage
6. High/Low temperatures (*indicate the exact one)*
7. Inadequate/excessive rainfall (*indicate the exact one*)
8. Late onset
9. Early cessation of rainfall

Key for types of crop in h/hold (O4)
1. Maize
2. Sorghum
3. Millet
4. Cowpeas
5. Pigeon peas
6. Beans
7. Green grams
8. Fodder crops
9. Cassava
10. Yams

O6-O8 (Indicate the quantity e.g. 500/1 (Quantity/unit of measure)
1. Kilogram
2. 50 kg bag
3. 90 Kg bag
4. Bunch
5. Piece
6. Heap
7. Debe
8. Gorogoro/kasuku (2 kg)
9. Basket
10. Crate

10. Late onset and early cessation of rainfall 11. Drought 12. Floods 13. Inadequate extension services 14. Cultural belief and practices 15. Insect pest attacks 16. Plant diseases 17. Wildlife conflict 18. Land not arable 19. Soil erosion 20. Others(specify)	11. Avocado 12. Sweet potatoes 13. Arrow roots 14. Bananas 15. Vegetables (Specify) 16. Coffee 17. Others (specify)	11. Others(specify)

O. FARMING PRACTICES

P1. What is the major cropping system on your farm? 1. Mono cropping 2. Intercropping 3. Mixed cropping 4. Agro forestry 5. Crop rotation 6. Other (specify)	P2. Methods of land preparation 1. Ox plough 2. Tractor 3. Manual (jembe) 4. Other (specify)	P3. Do you have any cover crops on your farm? 1. Yes 2. No If yes, specify	P4. Do you mulch your crops? 1. Yes 2. No	P5. Are you aware about conservation agriculture (CA)? 1. Yes 2. No	P6. How did you get to know about CA 1. Relative 2. Neighbor 3.Project/NGO 4.Government extension 5. Other (specify)	P7. Do you practice it on your farm? 1. Yes 2. No	P8. If no, what are the reasons? 1. Lack of knowledge 2. Small farm size 3. Expensive 4. No specific reason 5. Not profitable (explain) 6. Risk prone e.g. pests and diseases 7. Other(specify)

P. HOW DOES THE HOUSEHOLD OBTAIN SEEDS FOR THE MAIN STAPLE CROP FOR PLANTING?

Q1. Staple Crop	Q2. Means of obtaining seeds 1. Buy seeds 2. Save seeds 3. Receives seeds for free 4. Borrow seeds	Q3. Mention Source 1. Own seed 2. Government 3. Agro-vet 4. Neighbours 5. Relatives	Q4. How often? 1. Always 2. Sometimes 3. Never

	5. Other (specify)	6. Farmers' Associations 7. NGOs 8. Other (Specify)	

Q. AGRICULTURAL INPUTS FOR CROP PRODUCTION

R1. Inputs for coffee *(For use in Ethiopia and Tanzania only)* 1.Commercial fertilizer 2. Compost 3. Crop Residue 4.Fungicides 5. Manure 6. Pesticides 7. Irrigation facilities 8. Hired manpower 9. Improved coffee variety 10. Other (Specify)	R1.1 Type of coffee farm 1. Shaded 2. Non shaded	R1.2 No. of Coffee Plots (*indicate size and specify unit of measurement)*	R1.3 No. of coffee trees (Total)	R1.4 Current Season (See codes in R 1) Did you have access Yes/No		R1.5 Previous Season (See codes in R1) Did you have access Yes/No		R1.6 In use for more than 10 years (See codes in R1)	R2. Name of Crop	R2.1 Inputs 1.Commercial fertilizer 2. Compost 3. Crop Residue 4.Fungicides 5. Manure 6. Pesticides 7. Irrigation facilities 8. Manpower a)Hired manpower b)Household manpower 9. Improved coffee/seed variety 10. Other (Specify)	R2.2 Value inputs *(In local currency)*
				Expected	Actual	Expected	Actual				

R. CAUSES OF CROP DAMAGE AND LOSS

S1. Major causes of crop losses (in the past 12 months)	
S1. List crop(s) (use key)	**S2. Causes (use key) – if possible name the species e.g. coffee berry borer**
Crops 1. Maize 2. Sorghum 3. Millet 4. Cowpeas 5. Pigeon peas 6. Beans 7. Green grams 8. Fodder crops 9. Cassava 10. Yams 11. Avocado 12. Sweet potatoes 13. Arrowroots 14. Bananas 15. Vegetables (specify) 16. Coffee **17.** Others (specify)	**Causes** 1. Insects 2. Diseases (*name species where possible*) 3. Weeds *(name species where possible)* 4. Poor seed quality 5. Drought 6. Floods 7. Inadequate rainfall 8. Soil Erosion 9. Land not arable (soil fertility/moisture) 10. Frost 11. Excessive rainfall 12. Late onset of rainfall 13. Early cessation of rainfall 14. Strong winds 15. High/Low temperatures 16. Wildlife damage (*Indicate species where possible*) *17.* Domestic animal damage *(Indicate species where possible)* **18.** Others (specify)

S. IF DAMAGE WAS CAUSED BY INSECTS WHICH INSECT PESTS CAUSED THE MOST LOSSES?

T1. List Crop(s)		T2. Name pest(s) –(*if English name is not known use local name*)				T3. Estimate amount of damage (%)			
		Pre- harvest pest(s)		Post-harvest pest(s)		Pre-harvest loss		Post-harvest loss	
Crop	Acreage	LR	SR	LR	SR	LR	SR	LR	SR

T. CROP PEST CONTROL PRACTICES

U1. Traditional methods 1.Crop rotation 2.Trap cropping 3.Early planting 4.Mixed cropping 5. Using ash 6.Sanitation 7. Other (Specify)	U2. Biological methods 1.Predators 2.Parasitoids 3.Microbial agents/Bio-pesticides 4.Botanicals 5. Other (Specify)	U3. Mechanical methods 1.Handpicking 2.Shaking 3.Spraying with water 4. Other (Specify)	U4. Chemical methods 1.Insecticides 2.Fungicides 3.Bactericides 4.Herbicides 5. Other (Specify)	U5. Do you practice integrated pest management? 1.Yes 2.No *(If no, answer the succeeding table)*	U6. If Yes, indicate the sources of information about the practice 1. Relative 2. Neighbor 3. NGO 4. CBOs 5. Barazas/chief's meetings 6. Media (TV, radio, newspaper) 7. Research institutions/universities 8. Government extension 9. Farmers' associations 10. Other (specify)

U7. BARRIERS TO PEST MANAGEMENT

U7 Barriers to pest management	
Option	**Barrier (specify)**
Traditional	
Biological	
Mechanical	
Chemical	
IPM	
	Key 1. Lack of technical information 2. Affordability 3. Lack of technical know-how 4. Lack of/inadequate extension services 5. Inaccessible methods 6. Cultural/religious barriers 7. Other (specify)

U. PESTICIDE USE

(*Ask the farmer what pesticides are used to control insect pests, plant diseases and weeds)*

V1. List Crop	V2. Name pesticide used	V3. Others (specify)	V4. At what stage do you apply the pesticides? **(Key)** 1. Before pests attack 2. Once pests appear on some plants 3. When majority of plants have been attacked 4. When all plants are pest-infested	V5. Effectiveness of the pesticides (**Key**) 1. Very effective 2. Moderate **3.** Ineffective

V. PEST MONITORING

	Response (use key)
W1. Do you practice monitoring of pests on your farm? 1.Yes 2.No	
W1.1 If yes, how often do you monitor? 1.Once a week 2.Twice a week 3. Twice a month 4..Once a month 5.Twice a season 6. Once a season 7.Other (specify)	
W2. What monitoring method(s) do you use? 1.Visual 2.Traps 3.Other (specify)	
W2.1 If no, give reasons	

W. Have there been any changes in pest management practices in the last 10 years? 1. Yes 2. No ____________________________

X1. If yes, please give reasons for the change

____

____

____

____

____

X2. If damage was caused by diseases, indicate the disease and the amount of damage/loss caused

X2.1. List Crop(s)		X2.2. Name disease(s) –(*if English name is not known use local name*)		X2.3. Estimate amount of damage (%)	
		Pre- harvest diseases		Pre-harvest loss	
Crop	Acreage	Long Rains	Short Rains	Long Rains	Short Rains

X. POLLINATION

Y1. Does your household own any beehives 1. Yes 2. No

Y1.2 If yes, how many beehives does your household own? ___________________________

Y2. Apart from honey production, what other benefits do you derive from honey production?
____

Y3. How many kilos of honey do you produce per year? ______________________________

Y4. Has the honey production in your household increased/decreased/remained the same in the past 10 years?

Y5. If yes, indicate the reason for change

____

____

____

Y6. What is the main reason for producing honey in your household?

1. Domestic use
2. Domestic use and sales
3. For sale only
4. Other (Specify)

Y7. Do you have access to wild honey? 1. Yes 2. No _____

Y7.1 If yes, how do you access it?

1. Collected by household member
2. Bought
3. Received from neighbor/relative
4. Other (Specify)____

Y. WILDLIFE DAMAGE

Z1. Have you experienced any wildlife damage in your farm? 1. Yes 2. No ______________

Z1.2 If yes, what kind of damage?

Z1.2 Type of damage **(Key)**	Z1.3 Change in frequency **(Key)**	Z1.4 Estimated loss (*In cash or in volume)*	Z1.5 Species responsible for damage	Z1.6 Crop Species damaged	Z1.7 Actions taken 1. Yes 2. No.	Z1.8 Measures taken to prevent damage

Key for Z1.2 Type of damage

1. Damage to staple crops

2. Damage to cash crops
3. Damage to fruits/horticulture
4. Damage to assets/property
5. Damage to humans
6. Other (Specify)

Key for Z1.3 Change

1. Increased
2. Decreased
3. Remain the sam

Appendix Table 2. Basic household characteristics of the transact

	N	Minimum	Maximum	Mean	Std. Deviation
Age of HH head	300	20	90	43.6333	13.20531
Highest level of education	300	Primary education	No formal education	3.4567	2.84754
Household size	300	1	16	5.8867	2.24588

Appendix Table 3. Correlation of socioeconomic characteristics and climate-related shocks

	HH size	social net. W	HH education	Radio	Cell Phone	Market	weather forecast	Drought	Below av. rainfall	Erratic Rain Fall	Soil erosion
HH size	1										
social net.w	-0.091	1									
HH education	0.104	-0.018	1								
Radio	-0.05	.173*	0.045	1							
Cellphone	-0.021	.164*	.173**	.126*	1						
Market	-0.051	-0.101	-0.035	0.035	-0.041	1					
weather	0.063	-0.083	0.085	.270**	.231**	-0.003	1				

forecast											
Drought	0.054	0.075	0.072	-0.054	-0.044	0.008	0.084	1			
Below av. rainfall	-0.086	0.011	-0.07	-0.084	-0.016	0.011	0.082	-.122*	1		
Erratic Rain Fall	-0.04	0.14	0.001	-0.009	0.074	-0.044	.240**	0.113	.209**	1	
Soil erosion	-0.042	-0.001	0.072	0.038	.134*	-0.029	0.007	-0.022	-0.073	0.03	1

*. Correlation is significant at the 0.05 level (2-tailed).**. Correlation is significant at the 0.01 level (2-tailed).

HHs=Household size, SNW=group in social net-works, HHE=highest level of education for household head, WF=access to weather forecast of their locality, B Av. rain= effect of below average rain fall, Err= erratic rain fall effect

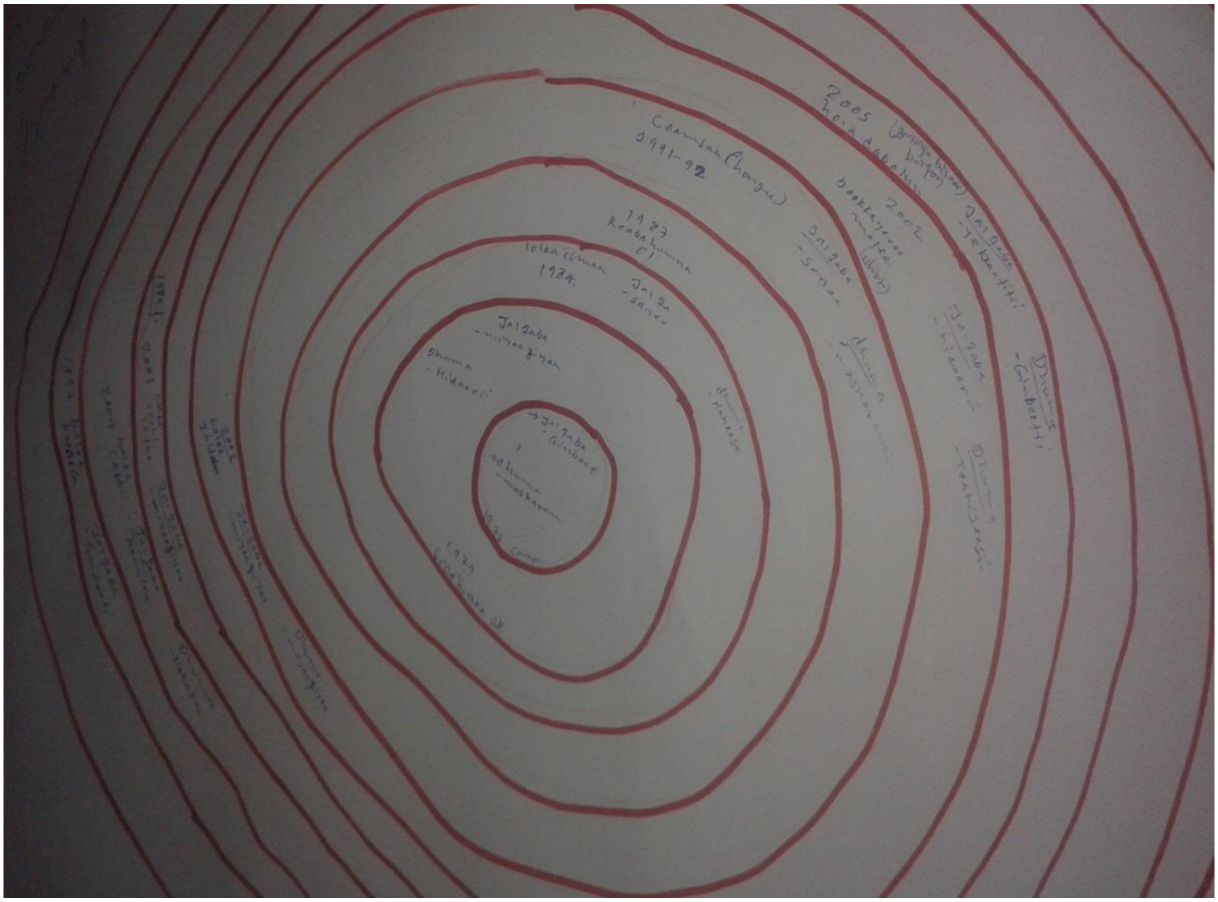
Appendix Table 4.Asset and infrastructure available for the households

		Count	%
Social safety nets	Farmers' Association	105	59.3
	Youth union	7	4.0
	Credit /Saving group	2	1.1
	Community Based Organization	31	17.5
	Water Resource Users Association	3	1.7
Help received from group safety net	Credit	19	10.7
	Technical/Equipment support	17	9.6
	Harvesting	27	15.3
	Weeding	47	26.6
Source of Household Income	Subsistence Farming	11	3.7
	Cash Crop Farming	277	92.3
	Wood work	3	5.6
	Non-permanent (Wage)	4	7.4
Residence			
Business Building		4	
Toilet		300	
Television		17	
Radio		164	
Cellphone		192	
Roof material of dwelling	Thatch(grass)	84	28.
	Iron roof sheets	216	72.
Access to Electricity		113	37.7
Access to (owner) of Mobile		206	68.7
Secondary school		300	37.7
Access to Medical enter		199	66.3
Access to Market		184	61.5
Access to Grocery(Agricultural inputs		6	2
Used Improved Coffee variety currently		101	33.8
Used Improved Coffee variety previous		65	21.7
Access to Water point		298	99.3
Access to weather forecast		201	67.7

Appendix Table 5. Weight and normalized value for vulnerability variables

	vulnerability variables	factor score Setema	factor score Diffo	factor score Ageyo	normalized value for Setema	normalized value Diffo	normalized value for Ageyo
Adaptive capacity	Access to Secondary School	0.621	0.51	0.704	0.74	0.93	0
	Access to Medical center	0.508	0.686	0.778	1	1	0
	Access to Electricity	0.481	0.46	0.471	0.69	1	0.41
	Group of social safety net in which the HH are member	-0.352	0.404	-0.411	-1	1	0.12
	Age of the HH head	-0.673	0.775	0.663	0	0	0
	Highest level of education of the HH head	-0.659	0.611	0.544	1	1	0.117
	Access to Cellphone	0.533	0.502	0.514	0	1	0.15
	Roof material for the main dwelling unit	0.466	-0.476	0.772	0	1	0.09
	Use of improved Coffee variety currently	0.436	0.507	-0.609	0	0.35	0
	Access to Market	0.521	-0.6	-0.7	1	1	0.161
	help received from group safety net group	0.48	0.467	0.45	0	1	0.161
	Access to weather forecasts in local area	0.697	0.627	0.506	0	1	0

	Use of improved Coffee variety previous	0.644	0.543	-0.484	0.81	-0.75	0.25
	Main Source of Household Income	-0.557	0.579	0.593	0.25	0	1
	Household size (currently living in the household)	0.55	0.559	-0.498	0.23	1	0.20
	Sex of the respondent	0.637	0.64	0.494	-0.62	1	0.54
	Access to Radio	-0.471	0.518	0.588	0	0.93	0
Exposure	Animal Disease	0.767	0.479	0.512	0.41	1	0
	Crop Loss During Storage	0.541	0.663	0.578	0.157	1	0
	Insect Pest Attack on Crop Before Harvest	0.536	0.565	0.562	0	1	0.047
	Plant Disease	0.424	0.567	-0.719	0	0.15	0.02
	Below average rainfall shock	0.684	0.549	0.541	0	1	0.5
	Erratic Rainfall shock	0.661	0.637	0.612	0	1	0.41
	Drought shock	-0.558	0.536	0.549	0	1	0.007
	Wildlife Damage to Crop	0.736	0.708	0.532	0	0.67	0.0512
	Loss of top soil (Soil Erosion)	0.687	-0.677	0.535	0	1	0.83
Sensitivity	effect of Erratic Rainfall pattern	0.79	0.544	0.504	0.063	1	0
	effect of plant disease	0.709	-0.66	0.462	0	1	0.378
	effect of crop loss during storage	-0.533	-0.606	-0.472	1	0.375	0



Appendix Figure 1.Community map of the past disaster events in the study area

Appendix Figure 2. Male and female groups participating in focus group discussion