SESAME PRODUCTION, CLIMATE CHANGE ADAPTATION AND FOOD SECURITY IN WESTERN ETHIOPIA

Gemechis Mersha Debela

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ADDIS ABABA UNIVERSITY

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Internal Examiner Bamlaku Alamirew (Ph.D)	Sign	
Advisor Endawork Assefa (Ph.D)	Sign	Date 31.08.20
Co- Advisor	Sign	Date

Chair of Department or Graduate Program Coordinator

ii

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Name:-Gemechis Mersha Debela

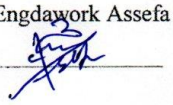
Signature:

Date: - August, 2020

Place: - Addis Ababa

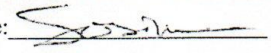
Date of submission: March, 2020

This dissertation has been submitted for examination with my approval as University supervisor.

Supervisor name: - Engdawork Assefa (PhD.)
Signature: 

Co-internal Supervisor: Dawit Diriba (PhD.)

Signature:

Co-external Supervisor: Sosina Bezu (PhD.)
Signature: 

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Sesame Production, Climate Change Adaptation and Food Security in Western Ethiopia

ABSTRACT

Ethiopia is the country mainly vulnerable to climate change which has already posed grave threats to agricultural production, food security and human wellbeing. The purpose of this study is to examine sesame production, vulnerability, adaptation and food security relationship of smallholder farmers in West Ethiopia. Specifically, it is to examine the determining factors of farmers' decision to participate in sesame production; to explore adaptation options and identify factors impacting smallholders' decision in practicing adaptation to climate change measures; climate change; to examine the status and determinants of food security of smallholder farmers'; to evaluate the impact of climate change adaptation options sesame production and household food security. The research employed key informant interviews, focused group discussions and a survey of 400 sampled households to collect data from the study area. Descriptive methods, index, and econometrics models were used to analyze the data. Descriptive statistics such as frequency, mean, chi-square, t-tests, and one way ANOVA were used. Double-hurdel model (probit and truncated), rainfall satisfaction index, multinomial logit model, household food insecurity access scale, binary logit model and two stage least square model were employed to examine the data. The result indicates that sesame production decision is significantly constrained by farmers' resource endowment and market information. Smallholders with more education, land, food access and credit access are more likely to plant sesame. The study discloses that households experienced higher exposure to climate change and variability. The result reveal that agronomic practices, livelihood diversification, soil and water conservation and small-scale irrigation were the main adaptation strategies to overcome the adverse of changing climate in the study area. It is also observed that adopting agronomic practices is significantly and positively impacted by availability of early warning system, social capital and number of crop failure experience; while market distance and farm size negatively influenced it. Soil and water conservation practices are influenced positively by farm size, market distance and existence of early warning systems. Further, access to credit, social capital, and educational status of household heads positively affected adoption of small-scale irrigation. The results revealed that 65.8% of sampled households are food secure, while the remaining is not. The results shows the effectiveness of climate adaptation strategies namely agronomic practices, small-scale irrigation and soil and water conservation in reducing climatic hazards and ensuring household food security. Additionally, land holding, family size and livestock ownership are significant factors influencing household food security. The study further indicates that adoption of soil and water conservation, livelihood diversification and employing different agronomic practices has significant impact on the level of sesame production. The result also implicitly indicated that farmers continued to adapt sesame production under changing climate and it contributes to farmers' food security enhancement. The result imply programs that endorse farmers' access to credit, alternative income earning sources, and establishing updated sesame market price information flow and appropriate selling channels would be of paramount importance in improving and shifting rural farming in to market-oriented and export potential high value crops like sesame. The study further suggests the importance of developing resilience-building climate change adaptation strategies. Accordingly, a policy that promotes the adoption of agronomic practices, livelihood diversification, soil and water conservation and small-scale irrigation practices should be essential in food security program and improvement of sesame production in the study area. Moreover, in order to enhance the role of adoption of adaptation options in reducing the impact of changing climate the policy should give emphasis for: creating effective early warning system and efficient micro-finance institutions, improving infrastructures and increasing farmers' climate adaptation awareness and stand by.

Keywords: *sesame production, climate change exposure, adaptation, food security, West Ethiopia*

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DEDICATION

To my beloved family—Mom & Dad—to my darling sis and bros—Rahel-rich, Abdi-tobe & Aboma-obex Mersha… Love you all! Stay blessed!

List of original papers

This dissertation is based on the following four original papers, which are listed from 1–4.

Paper 1: Determinants of Smallholders' Export-Potential Cash Crop Production Decision in Ethiopia: the Case of Sesame Sector**.**

Paper 2: Smallholder Sesame Producers' Adaptation Decisions to Climate Change and its Determinants in Western Ethiopia

Paper 3: Household Food Security Status and Determinants under the Variable and Changing Climate in Western Ethiopia

Paper 4: Climate Change Adaptation and its Impact on Food Security and Sesame Production in Western Ethiopia

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ABBREVIATION AND ACRONYMS

ATA	Agricultural Transformation Agency
CC	Contingency Coefficient
CSA	Central Statistics Agency
DAs	Development Agents
D-H	Double-Hurdle
FAD	Food Availability Decline
FANTA	Food and Nutrition Technical Assistance
FAO	Food and Agriculture Organization
FDRE	Federal Democratic Republic of Ethiopia
FED	Food Entitlement Decline
FGDs	Focused Group Discussions
GDP	Gross Domestic Product
HFIAS	Household Food Insecurity Assess Scale
IIA	Irrelevant Alternatives
ML	Maximum Likelihood
MNL	Multinomial Logit
MoA	Ministry of Agriculture
MoFED	Ministry of Finance and Economic Development
NGOs	Non- Government Organizations
NMA	National Meteorological Agency
SWC	Soil and Water Conservation
TLU	Tropical Livestock Unit
UNFCCC	United Nations Framework Convention on Climate Change
VIF	Variance-Inflating Factor

Chapter One

1. INTRODUCTION

1.1 Background of the Study

Climate change has now become one of the main global issues causing arising unprecedented impact on the living of mass agrarian households in many developing countries. It is observed via increasing disparity in the weather conditions, including temperature, rainfall, and wind. Scientific researches are frequently reporting that the climate change is happening and anticipated to exacerbate in upcoming decades (Stern, 2006; IPCC, 2007b; IPCC, 2014, IPCC, 2018). The changing climate is already having damaging shocks on human health, food security, biodiversity, energy, etc (Schlenker and Lobell, 2010; Thornton *et al*. 2011). The underdeveloped countries are highly exposed the changing climate due to their high dependency on nature that are susceptible and their poor capacity to adapt (Review, 2016; MEA, 2005). Human ability to limit further catastrophic climate changes and to adapt to both past and coming variation are very crucial to our species continues existence.

Africa, according to IPCC (2014), is mostly susceptible to climate change due to the fact that the continent is under multiple stresses and of poor adaptive capacity. Studies showed that in Africa, agriculture comprises about 30% of GDP, 50% of total export earnings and 70% of rural employment (Parry et al 2005; Devèze 2011). In most Sub-Saharan African (SSA) countries, the high vulnerability of agriculture has already made poverty eradication difficult (Benhin 2008; Kang et al 2009; Müller et al 2011; Field et al 2014) and compromises the farmers' ability to achieve food security (Thornton et al., 2008; Hertel and Rosch, 2010; McDowell and Hess, 2012). Recently, East Africa has faced recurrent incidence of both excessive (Webster et al., 1999; Latif et al., 1999) and scarce rainfall (Williams and Funk, 2011; Nicholson, 2015), and a raising recurring average temperature (Funk et al., 2012). It is also not uncommon to frequently see Ethiopia mentioned as one of the most vulnerable country with low adaptation ability to climate change (Parry et al. 2007; WB 2010; Conway & Schipper, 2011; Bewket et al. 2015).

In Ethiopia, like other African countries, rain-fed agriculture is the hub of the economy. Agriculture remains the backbone of Ethiopian economy accounting for 40.2% of GDP, 80% of employment, and 70% of export earnings (UNDP, 2015). About 85% of its population lives in rural areas depending on rain-fed agriculture for living and employment (Negatu et al. 2016). High dependency of the country's economy on rain-fed agriculture, added to the persistent poverty, is making minor climate change and variability a major threat for the country (Alebachew, 2011). In Ethiopia climate change is manifested as changes in precipitation trends and unpredictability, and temperature, which raises the country's incidence of both droughts and floods (UNDP 2008). According to Alebachew 2011, these climatic hazards, particularly drought, has been more pronounced in recent decades and has become a main happening threatening the living of many smallholders in Ethiopia (Bewket et al. 2015).

Ethiopian agriculture is mainly managed and operated by smallholder subsistence farmers. For instance, about 98% of the total area under crop cultivation and 97% of crop production is operated by private peasant holders, with average landholding size of 1.16 ha (CSA 2009; Matouš et al 2013). Whereas, the expected agricultural sector progress and then economic growth has been hindered by the limited financial, human and physical resource capacity of the country (Deressa 2007; Gebremedhin et al. 2009; Mideksa 2010). Ethiopian government has invested a lot on the agricultural sector by the hope of making it a driving force to improve the overall economy. Nonetheless, the sector is growing by far less than the growth rates of country's population and associated food demand (Gebremedhin et al. 2009). Farmers' ability to adapt to adverse climate shocks has been hampered by lack of appropriate policy interventions and technology options. These further exacerbate food insecurity and poverty in the country (Degefe, 2002; Awulachew et al., 2005; Kedir, 2005; Lencha, 2008).

In Ethiopia, it is still believed that improvement of agricultural productivity is an important solution in addressing the problems of food insecurity and poverty. Accordingly, so as to bring high agricultural productivity attempts have been going on through promotions of climate change adaptations, improved agricultural technologies and improving the efficiency of production of both cash crops and cereal crops in Ethiopia (Sinafikeh et al., 2010; Yu and Nin-Pratt, 2014). Crop production constitutes a major share in agricultural production and accounted

for 31.5 percent of GDP in 2010/11 and 30.4 percent in 2011/12. Thus, increasing crop production enhances agricultural output and gross domestic product, and is essential to improve the income and living conditions of the majority of citizens (FAO, 2015).

Oilseeds, one among high value crop, are the mainstay of the rural and national economy in Ethiopia. It is the second largest foreign currency generating crop for the country after coffee and already more than 3.7 million smallholders are earning their living from oilseeds production (CSA, 2014). One of the major oilseeds, which become a focus of this study, for which Ethiopia is known in the international market, is sesame. It represents, on average, 32 percent of the total cultivated area under oilseed production for the period 2005-2012, which represents 3 percent of the total cultivated area for major crops CSA (2013). In 2014, sesame production was dominated by more than 867, 347 small-scale farmers cultivating a total of 420,495 hectares of land in Ethiopia. The total production of sesame was 440 million tons in 2013 (CSA 2014). Although there was an increase in average yields from 2000 to 2012 (FAOSTAT, 2013), they are still considered low compared to the full potential sesame production.

Native to Sub-Saharan Africa, though sesame is well-adapted to Ethiopia's climate it is also exposed to the impact of the looming climate change and variability. If the rain is over, floods are the largest climate threat to sesame: they have potential to decrease stocks for export, severely limiting the sesame value chain (USIAD, 2017). Oxfam study by Kostka,G. and J. Scharrer, 2011 showed that sesame is a plant that is particularly sensitive to weather hazards. Farmers consistently reported sesame crop losses between 25 to 100 percent during the last two years. Over the last few years, sesame farmers in Metekel and Assosa reported an increase in temperatures, erratic rainfall, and weather hazards such as windstorms and 'ice-rain', all having a severe impact on their sesame crop. Farmers tend to attribute these occurrences to a structural shift in climate conditions (Kostka and Scharrer, 2011). Similarly, Sesame farmers in Humera mentioned drought/inadequacy of rain as the most important production problem (Sorsa, 2009). Although climate variability and change could increase risks to sesame production, many of its characteristics, such as drought tolerance and high thermal tolerance, can help offset these risks (USIAD, 2017).

In addition to the climate impact, smallholder sesame farmers' decision to produce, level of production participation is constrained by many other factors. The main constraints are: low use of improved seeds, fertilizers and cultivars; biotic stress and lack of knowledge on adequate post-harvest crop management; poor improved inputs supply system and insufficient extension services; and little research support to increase yields (ATA, 2015, FAO, 2015, Sorsa, 2009). These challenges lead to low yield and operation under capacity. Wijnands et al. (2007) stated that the potential to increase production is not being fully exploited, though higher input use and improved technologies and seeds could double the productivity per hectare, and thus approach the potential yield estimated by FAO, which is about 16 quintals/ha. Government Sesame Development Strategy has planned to generate sesame technologies that improve the productivity and quality of sesame through a demand-driven and agro-ecology based approach (ATA, 2015).

Despite concern on the potential adverse effects of climate change on Ethiopia's agricultural sector, high recognition of adaptation to reduce vulnerability to climate change and enhance household food security are urgently demanded. This could be achieved, according to IPCC, 2014, by making rural communities better able to adjust to the changing climate, help them to cope up with adverse consequences, and by moderating potential damages. Thus, a research need to be undertaken to better understand the dominantly sesame producing farmers' vulnerability to climate change, to identify adaptation options farmers used, and to evaluate the potential impact of adaptation on farmers food security and level of sesame production. This would support adaptation process through policies and programs guided by scientific evidence. It is also invaluable policy input to critically identify the potential determinants of smallholders' sesame production decision.

1.2 General Problem Description

A study on vulnerability in Africa identified Ethiopia as one of the countries' most vulnerable to climate variability and change (Thornton et al. 2006). The country's economy heavily relies upon the rain fed agricultural sector. The productive performance of agricultural sector has been severely compromised by climate change. Empirical evidence reveals that adverse changes in climate, combined with long-term factors (technology, environmental, institutional) led to soil

degradation and a decline in yield per hectare (Anley et al. 2007; Shiferaw & Holden, 1999). In addition to that, deterioration of pastures during droughts periods have resulted in poor health and death of livestock impacting food and livelihood of smallholder farmers (Bewket et al. 2015; Niang et al. 2014; NMA, 2007).

In Sub-Saharan Africa, food security is at the core of the ongoing debate regarding the implication of climate change. Climate change, particularly rainfall variability and associated droughts and floods have been causing food insecurity in Ethiopia (Rosell, 2011; Seleshi & Zanke, 2004) and posed more threats to further reduce the performance of the economy (Arndt et al. 2011). It has now becoming a global consensus that adaptation options are urgently needed to minimize climate impacts (Rosenzweig et al. 2013). Ethiopian government, in recognizing adaptation as a critical response to the impacts of climate change, have been designed different national policies, programs and strategies that intend to address the impact (NPC, 2016; EPCC, 2015; FDRE, 2011; MoFED, 2010; NMA, 2007; MoFED, 2006). Similarly, local communities have been adapting to climate change so as to minimize its adverse impact and to support them in producing enough foods to meet their nutritional needs. Despite the progress made so far to design and implement such policies and strategies, and promote adaptation options, the level of adoption of adaptation options that would reduce vulnerability and enhance food security is below expectation (EPCC, 2015).

Though different studies have been undertaken, to estimate the impact of climate change on agriculture (Deressa, 2007; NMA, 2007; Kidane et al. 2006) they communicate limited insight in to adaptation process. It is indicated that the impact models do not investigate the practical feasibility of adaptations, the conditions that might assist or hamper adoption of adaptive options, or the actual types of adaptations employed (Adger and Kelly, 1999). Similarly, number of researches seek to understand the underlying factors affecting farmers decision to adopt adaptation options (Hassan & Nhemachena, 2008; Deressa et al. 2009; Tazeze et al. 2012; Tesso et al. 2012b; Balew et al. 2014; Debalke, 2014; Wood et al., 2014). Even though these studies provide important information on factors regulating the decision to adopt, the results are not conclusive and there is no consistency in the outcomes of studies regarding the type of adaptation options and its determinant factors.

Climate change adaptation is a complex phenomenon since there is no-size fits all adaptation option. Adaptation options will vary across regions (Berry et al. 2006) based on agro-ecological contexts, socio-economic factors (Adger et al. 2009), climatic impacts, and existing infrastructure and capacity. Given these heterogeneity of different areas, targeting the right adaptation options to different community remains a big challenge. This suggests that an adaptation options and a factor in a certain locality at a time might not be true in another locality. It is therefore, vital to carry out area-specific studies. The knowledge on confluence of factors assists policy to strengthen adaptation that would help to improve household food security.

Further, few studies (Deressa et al., 2009; Tesso et al. 2012b; Balew et al. 2014; Debalke 2014) investigated factors affecting the choice of adaptation methods. Nonetheless, they are far from reaching on similar consensus and revealed disparity in factors that influences farmers' decision to practice different adaptation methods in various areas of studies. This gap in obtaining clear scientific evidence has become stumbling block for the efforts to design appropriate development policies and interventions. Therefore, context specific assessment of the determinants of smallholders' decision in response to climate change is decisive to pinpoint main practices that could improve the use of appropriate adaptation strategies.

In Africa, most of the researches on the impact of climate change on food security focuses on changes in crop yields and food production (Gregory et al. 2005; Seo and Mendelsohn, 2008; Kurukulasuriya and Mendelsohn, 2008; Nianget al. 2014; Porter et al. 2014). In Ethiopia, studies have been undertaken to measure the extent and determinants of food insecurity (Bogale & Shimelis, 2009; Hadleya et al. 2011; Abebaw et al. 2011). Those studies dominantly focused on analyzing the demographic, socio-economic and institutional factors that affect food security, but failed to address the climate factors that are believed to affect food security (Demeke et al. 2011) and none have shown how adaptation options impact food security status. Additionally, a recent study examining determinants of food security indicates the need to be context specific in identifying factors that influence specific investment in food security projects and programs (Beyene, 2014).

Studies by Ali & Erenstein (2017); Asfaw et al. (2015); Gebrehiwot & Van Der Veen (2015) and di Falco et al. (2011) are few attempts to measure the impact of adaptation on food security. While these impact studies provide valuable information, the results from these studies are highly fragmented and inadequate to address local context. For instance, study by di Falco et al. (2011) which focus only on agricultural productivity provides a partial assessment of food security-adaptation relationship. Notwithstanding several research efforts, none of these studies have examined the relative impact of different adaptation options in response to climate change on food security. Similarly, we have found no study that deals with the impact of different adaptation strategies specifically on sesame crop production. It is imperative to see any effort to investigate how farmer's decision to adopt different adaptation measures in response climate change affects household food security and level of sesame production in the study locality. This seems particularly relevant because most of the debate on the effect of climate change in agriculture has been focusing on the impact of climate change rather than on the role of adaptation.

On the other hand, climate change is bringing both opportunity and danger to the sesame production. Increased overall rainfall will likely have impact on seed viability and availability (USAID, 2017). Heavy rain and rising humidity can damage the sesame plant (Kostk & Scharrer, 2011) and in other areas drought become as the most important sesame production problem (Sorsa, 2009). Although climate variability and change could increase risks to sesame production, many of its characteristics, such as drought tolerance and high thermal tolerance, can help offset these risks (USIAD, 2017). However, rather than indicating the possibility of sesame production adversely affected by climate variability, none of the studies have shown whether the smallholder farmers are planting sesame as a climate change adaptation crop or not. Likewise, no study has tried to shown the relationship between sesame productions and food farmers' security. Understanding how sesame production is responding to climate change and its role in enhancing food security is of great importance in strengthening efforts of climate change adaptation and securing food for farmers.

Further, studies on Ethiopian Sesame sector are all most all dominated by sesame sector value chain analysis which indicates that both production and marketing of sesame were hampered by many constraints. Though there is high production potential, sesame production was characterized by low productivity and recently showing the declining trends (ATA, 2015), due to many constraints as indicated in different studies (FAO, 2015; Meijerink, 2014; Coates et al., 2011; SID-Consult, 2010; Sorsa, 2009; Wijnands et al., 2007). These studies, further, indicates that sesame face marketing constraints and hence losing opportunities of gaining high prices due to poor sesame quality, poor organization of sesame value chain, and underdeveloped market information system.

Nonetheless, most of the studies have assessed the general production and trade set up of the sesame sector by mainly focusing on the marketing aspects of the crops. By focusing on the common sesame production and marketing related problems which are mainly external to the individual farm households, the previous studies overlooked factors affecting the production decisions at individual household levels. Methodologically, they relied only on general descriptive assessment rather than rigorous statistic and econometric analysis. Yet, it is going to be invaluable to identify and analyze household specific factors which are hampering households from producing and achieving highest level of productivity and profitability.

To fill these gaps, in-depth investigation of area specific vulnerability and an understanding of the socio-economic, environmental, and institutional compulsions and constraints of smallholder farmers in sesame production and adopting adaptation options are imperative. Additionally, any analysis to find micro evidence on the impact of adaptation on household food security and level of sesame production is, we believe, of an invaluable importance. Therefore, the main purpose of the present study is to critically examine the four themes of research- sesame production, vulnerability, adaptation options, and food security relationship - of smallholder farmers in Western Ethiopia.

1.3 Objectives of the Study

The general objective of this research is to examine sesame production, climate change vulnerability, adaptation and food security relationship of smallholder farmers in West Ethiopia. The specific objectives of the research are to:

1. analyze the factors influencing farmers decision to produce sesame and level of participation in production;
2. assess farmers' vulnerability to climate change and identify factors constraining or facilitating farmers' decision to adopt adaptation options in response to climate change;
3. examine the status and determinants of food security of smallholder farmers' in the face of climate change in the study area and
4. evaluate the impact of adoption of adaptation to climate change on household food security and on the level sesame production

1.4 Research Questions

Given this, this study attempted to empirically address the following research questions;

1. What are the factors influencing smallholder farmers' decision to participate in sesame production and level of production?
2. How are farmers' adapting and what are the determinants of farmers' decisions to adopt adaptation options to climate change and variability?
3. What are the determinants and status of household food security in the study area under the changing climate?
4. How are the adoptions of climate adaptation option impacting the level of the smallholders' sesame production and house hold food security status?

1.5 Significance the Study

This study provides empirical evidence that link sesame production, vulnerability, adaptation and food security to guide informed policy decisions. It also provides detailed information on the determinants of sesame production decision that would be invaluable for all concerned body working on development of export potential and the second largest foreign exchange earning cash crop in Ethiopia--SESAME. Furthermore, the study sets a stage for an understanding of

vulnerability and adaptation options employed by local people in adapting to impacts of climate change for plausible area specific intervention. Likewise, assessing factors influencing rural household food security is very crucial as it provides information on household food security status that would help the policy makers for effective implementation of food security program. The study further provides information on the potential benefit that adaptation generate to improve household food security, and this information helps policy makers to give emphasis on adaptations in the process of policy design. Moreover, the study also tries to highlight how sesame production is related to climate change adaptation options and its role in enhancing smallholders' food security status. Finally, the findings of this study can contribute to the growing body of literature and can also be used as a reference material for future researchers on the area.

1.6 Scope and Limitations of the Study

This study draws on a comprehensive framework whereby underlying vulnerability factors, adaptation options, and the impact of adaptation on household food security and level of sesame production can be better captured. The study was based on the information generated from the sample household survey during a single cropping season using across-sectional data. Hence, theoretical analyses of this research are largely based on static models, in which production, adaptation and adoption decision process treated as a static phenomenon and issues of expectations and dynamic adjustments would be overlooked. Though, incorporation of dynamics and expectations into tractable models is vital in agricultural and environmental research for the foreseeable future, the dynamic model avenue was not included in this research.

1.7 Study Area Description

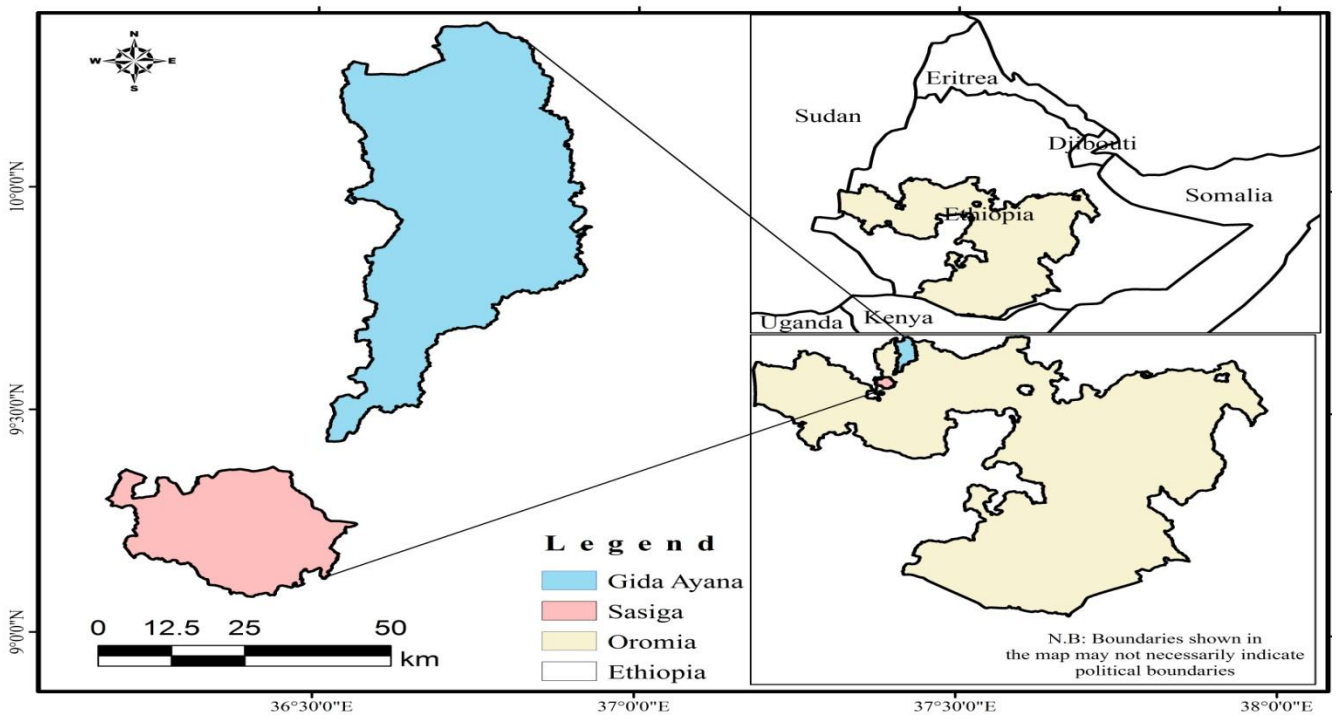
Geographically, sesame is produced in different parts of Ethiopia at an elevation from sea level of about 1500 meters. The dominant producers, who contribute over 83 percent to national production (CSA, 2011), are located in the regions of Tigray (West Tigray), Amhara (North Gonder), Oromia (East Wellega) and most recently, in Benishangul-Gumuz Region (Metekel). Based on temperature and rainfall requirements of sesame, there are high potential areas in Afar, SNNP and Somali regions where sesame production can be expanded into (ATA, 2015). Eastern and south Easter vast areas of Oromia have also huge potential of sesame production. This

indicates that critical empirical studies in these potential areas would be of vital importance for the country's efforts to expand sesame production. This study was undertaken in the western part of Ethiopia particularly in East Wellega zone of Oromia region. The zone is geographically located between 9° 31' 9" North latitude and 36° 45' 27" East longitudes. Based on the 2007 Census conducted by the CSA, this Zone has a total population of 1,213,503; with an area of 12,579.77 square kilometers and has a population density of 96.46. There are 18 districts in this zone, and two districts, namely Sasiga and Gida Ayana, were selected for this study.

Sasiga woreda is bordered on the south by Diga Leka, on the west by the Benishangul-Gumuz Region, on the northwest by Limmu, on the north by an exclave of the Benishangul-Gumuz Region and on the east by Guto Wayu. The administrative center of this woreda is Galo. The 2007 national census reported the total population for this woreda to be 80,814, of whom 41,326 were men and 39,488 were women. 2,573 or 3.18% of its population are urban dwellers. A survey of the land in this woreda shows that 11.9% is arable or cultivable, 2.8% is pasture, 1.6% is forest and the remainder 83.7% is swampy, marshy or otherwise unusable.

Gida Ayana is bordered on the south by Guto Wayu, on the west by Limmu, on the northwest by Ibantu, on the north by the Benishangul-Gumuz Region, and on the east by Horo Gudru Welega Zone. The administrative center of the woreda is Gida Ayana; other towns in Gida Ayana include Gutin and Kiremu. According to data from rural and agricultural development office the total population of the district is estimated to be about 142,408 out of which 66,918 (47%) are female and 75,490 (53%) male. A survey of the land in this woreda shows that 65.7% is arable or cultivable (61% was under annual crops), 22.8% pasture, 8.7% forest, and the remaining 2.8% is considered unusable. Sesame and khat are two important cash crops.

Figure 1: Location of the study area in Oromia regional state of Ethiopia



1.8 General Theoretical Framework

The mix of different theories, approaches and explanations is used to frame this study. Sustainable Livelihood Framework (SLF) was adopted as one of the main theoretical underpinning to lead the analysis of smallholder exposure and adaptation to climate change and its proceeding impact. This framework is very helpful to comprehend the link among livelihood climate exposure during crop production, their adaptation strategies and impact on food security and sesame production. The SLF consists of five blocks: the vulnerability context; livelihood assets; policy, institutions and procedures; livelihood strategies; and its outcomes. In this study, we refer to vulnerability or exposure as the climate change and its associated variability- rainfall shock and rising temperature. It largely impacts the accumulation of household assets as it directly affects livelihood strategies, institutional process and living outcomes of a society (DFID, 2000; Chambers and Conway, 1992).

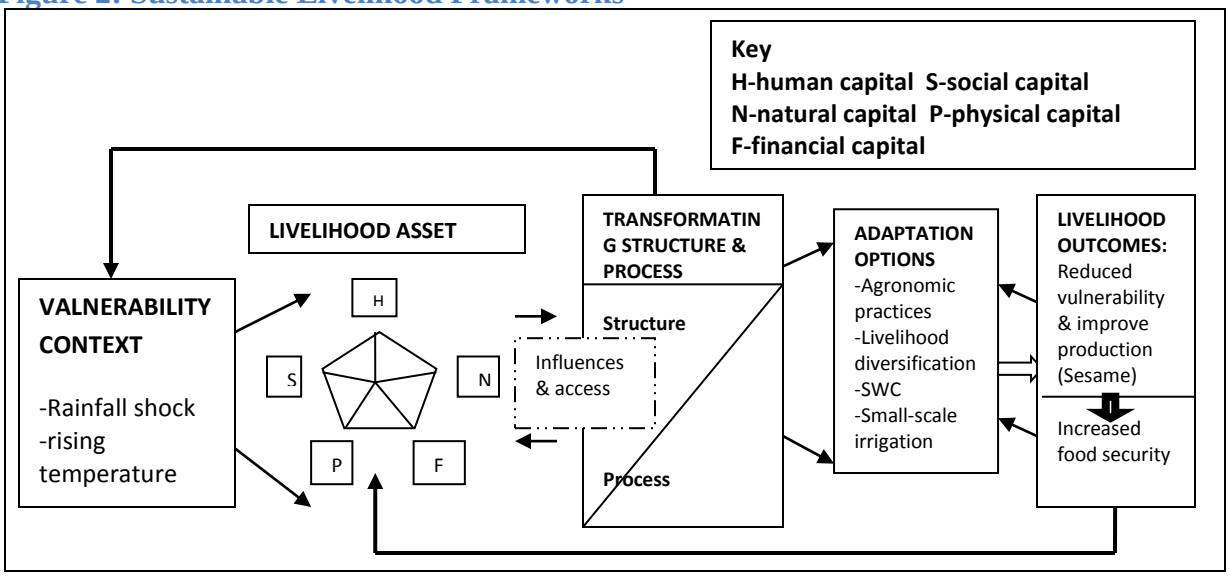
The livelihood asset is the situation of a possession and control of the combination of assets, or capital types, that smallholder farmers have with which to respond to vulnerability. Policy, institutions and processes describes the structures and processes that affect access and influence of adaptation options, the combination and type of household assets and the susceptibility to

environment. In this study context, policy and legislation issues have got less attention because most of the policy, and legislation issues should be seen at larger scale of analysis than the household level of analysis. Livelihood strategies mean variety of adaptation alternatives that farmers used in reaction to changing climate and to achieve their livelihood outcomes. And the livelihood outcome describes the achievements or outputs of the adaptation options and may include reduced vulnerability and increased production level and food security (DFID, 2000; Chambers & Conway, 1992).

In building analytical frame work it is of great importance to identify the underpinning assumptions. Contextually, the underlying assumption in SLF is that people pursue their living outcomes (like reduced exposure, and enhanced production and food self sufficiency) based on a array of household assets via the use of a variety of adaptation options. The adaptation options that people use to generate livelihood outcomes and the way they reinvest in asset building are driven by the transforming structures such as government or private sectors and by the institutional structures such as culture, norms, values and formal laws (DFID, 1999; Farrington et al. 1999).

As a main framework, this study used SLF because it is an essential device that enables us to grasp the linkage in between exposure to climate change, adaptation alternatives, sesame production and food security in a systematic and holistic ways. It provides a framework for analyzing adaptation options and livelihood assets that determine vulnerability of production and food security and the specific variables that affects those (Eakin & Luers, 2006). The inter relations among vulnerability context; livelihood assets; institutions and organizations that shape or constrains both livelihood assets and adaptation options that farmers used; and the livelihood outcomes resulted from this process and its impact on livelihood assets are portrayed in Figure 1 below.

Figure 2: Sustainable Livelihood Frameworks



Source: Adopted from Farrington et al. 1999; DFID, 2000; Chambers & Conway, 1992; Eakin & Luers, 2006, with own modification

It has been observed that the SLF is very useful for assessing the adaptive capacity of households to withstand rainfall and temperature shocks. In addition, apart from climate change risk, adaptation and impact framing, the determinants of smallholders' sesame production were framed under Agricultural Household Utility Maximization Model in chapter two. Moreover, to comprehensively assess livelihood climate risks, adaptation and its impact the demographic, environmental, institutional and economic explanations were used to frame food security analysis and presented in chapter four.

1.9 Methodological Approach

1.9.1 Pro mixed-method (qualitative and quantitative) approach arguments

In any scientific study, it is obvious that the way to conduct the research would be conceptualized in terms of the research philosophy subscribed to, the research strategy used and so the research instruments utilized. To counteract the argument of incompatibility in using either qualitative or quantitative approaches, there have been a few theorists (Datta, 1994; Reichardt & Rallis, 1994) who have suggested the possibility of the co-existence of the quantitative and qualitative approaches. They also showed how mixing both approaches could

enhance an understanding of social realities. This has contributed considerably to the emergence of the new approach known as ‘pragmatism ’or ‘compatibility theses. It is an approach under which one can generate data by multiple methods from both qualitative and quantitative traditions.

Reichardt and Rallis (1994) argued that the two paradigms are thought to be compatible because they share the tenets of theory-leadenness of facts, the fallibility of knowledge, in-determination of theory by the fact, and a value-ladened inquiry process. Similarly, Casebeer and Verhoef (1997) also argued qualitative and quantitative methods as part of a continuum of research with specific techniques selected based on the research objective. In line with this, Haase and Myers (1988) indicate that the two approaches can be combined because they share the goal of understanding the world in which we live. King et al. (1994) claim that both qualitative and quantitative research shares a unified logic and that the same rules of inference apply to both. According to Tashakkori and Teddlie (1998), mixed method studies are those that combine the qualitative and quantitative approaches to the research methodology of a single study or multi-phased study. Given the aforementioned importance of mixing qualitative and quantitative methods, the methodological framework of the current study was drawn from mixed method approach.

1.9.2 Sampling design

This study was based on the data obtained through a survey administered to sample farm households which was drawn through multi-stage sampling procedure research design. The three-stages that involves in the selection were Woredas, Kebeles and smallholder farmers. In the first stage, two woredas, namely Sasiga and Gida Ayana were purposively selected from the top five sesame growing woredas of East Wollega zone. Secondly, the study was included 50 percent of total sesame growing Kebeles from each of the two selected Woredas using simple random sampling method. Based on these criteria, five Kebeles was selected from each Woredas randomly.The kebeles selected from Sasiga woreda were Lalisa Bereda, Handura Balo, MilkiGudina, Karsa Mojo, Mada Jalala and Oda Gudina; while Agar Gutin 01, Warabo, Lalistu Angar, Dalasa Makanisa, Tulu Lenca and Andode Dicho were kebeles selected from Gida Ayana Woreda. Finally, 400 farm households were randomly selected from lists of names

of household head in the Kebeles using computer-generated random number table. The total sample was distributed to different sample Kebeles based on the probability proportional to their total sizes. The sampling frame was the list of households which was obtained from the Kebeles administration.

1.9.3 Sample size determination

Determining an appropriate sample size is a very important in any research as samples that are too small may hardly represent the population and lead to erroneous findings and recommendations. There are several approaches suggested to determine sample size. These include using a census for small populations, imitating a sample size of similar studies, using published tables, and using specified formulas to determine sample size (Israel, 1992). In addition to the purpose of the study and population size, three criteria usually need to be specified to determine the appropriate sample size: the level of precision, the level of confidence or risk, and the degree of variability in the attributes being measured (Miaoulis& Michener, 1976).

To obtain a representative sample size, for cross-sectional household survey the study employed the sample size determination formula given by Kothari (2004):

$$n = \frac{Z^2 Pq}{e^2} = \frac{1.96^{\ 2}\ \ 0.5\ \ 0.5}{0.05^{\ 2}} = 385$$

Where n is the sample size needed, Z is the inverse of the standard cumulative distribution that corresponds to the level of confidence, e is the desired level of precision, p is the estimated proportion of an attribute that is present in the population and q = 1-p. The value of Z is found from statistical table which contains the area under the normal curve of 95% confidence level.

In the determination of sample size where there is large population, but we do not know the variability in the proportion about the decision and extent of production, p = 0.5 is considered as suggested by Kothari (2004). Based on this, a total of 400 (15 households in addition to 385 samples) households were selected for the study from the two selected woredas and assuming a 95 percent confidence level and ± 5 percent precision.

1.9.4 Data sources and methods of data collection and Analysis

This research gathered and utilized both primary and secondary data. Given the diverse nature of the information needed on various aspects of this research, mixed method of data collection methods was required to generate adequate and reliable data that would be enhanced through triangulation.

Primary data collection methods

***1) Household Survey*:** In order to adequately address the research questions of this study, we employed semi-structured interview schedule. The interview schedule was designed based on four central research theme- sesame production, vulnerability, adaptation, and food security-that this study aimed to address. The survey addressed data on decision to produce sesame and its main determining factors. In addition, two climatic variables namely precipitation and temperature are gathered to assess the vulnerability of farm households to climatic shocks. Moreover, this survey instrument includes questions that helped to investigate whether farm households made some adjustments in their farming in response to long-term climate changes by adopting different adaptation options. Besides data on lists of adaptation options, the survey instrument included factors that limit and or aid adaptation options to change climate. The survey also included standard questions widely used to assess the food security status of each household and to examine determinants of household food security. Finally, the survey was conducted under the presence and close supervision of the researcher.

***2) Focused Group Discussions (FGDs) and Key Informant Interview*:** Qualitative information was gathered from purposively selected farmers, development agents, women and community leaders using checklists. This was important to have detail information that has been useful to draw the right conclusion from the survey work. Accordingly, we have conducted a total of six FGDs of which three were in *Sasiga*, and three in Gida Ayana Wereda. The focus groups were composed of six to eight elderly men and women whom we think (as suggested by local community and development agents) to have rich information on sesame production, climate change, adaptation, and food security. In-depth interviews with purposively selected key

informants were undertaken. Key informant interviews likewise, enabled the study to obtain climate information from people with long-term experience in the area as well as expert knowledge thus counterchecking the credibility of data from other sources.

Secondary data collection methods

Secondary data were gathered to supplement the primary data obtained. Documents, reports, and records maintained at Development Agents (DAs) centers, and districts agricultural offices were consulted as major sources of secondary data. The other major sources of secondary data were from both published materials and online resources of Central Statistics Agency (CSA) and Food and Agriculture Organization (FAO).

Analysis of Data

The determinant factors that influence the smallholders' participation in sesame production we analyzed using the double hurdle model **(D-H).** It empirically identifies factors affecting farmers' separate decision making regarding the sesame production participation using Probit-Model **(PM)** and level of production using Truncated-Model **(TR).** In addition to national meteorological data, two major indicators temperature and rainfall data were collected and used to assess farmers' exposure climate change in the study area. Rainfall Satisfaction Index **(RSI)** was used to capture rainfall variability. Then after confirming the presence of climate exposure and adaptation practices implemented by smallholders in response to changing climate, Multinomial Logit Model **(MNL)** were used to analyze factors that shape farmers' adaptation strategies. Before assessing the impact of adaptation on food security one must first understand the food security status and determinants of households in the study area. To identify the food secure and insecure households, Household Food Insecurity Assess Scale **(HFIAS)** was employed to captures the household's food insecurity status including the frequency of occurrence. Then we employed a binary logit model **(BLM)** to identify potential explanatory variables affecting household's food security. Finally, this study examined impact of climate change adaptation strategies for sesame production using Truncated Model **(TM)** and household food security using Two-stage least square **(2SLS).**

1.10 Organization of the study

This dissertation was organized in six chapters. This introductory chapter discussed the research context and research questions, general theoretical framework and direction in research design. Then, chapter two presented the determinant factors in sesame production decisions and level of production. The farmers' vulnerability, adaptation options and factors that determine farmer's decision to adopt adaptation options were discussed in chapter three. Chapter four examines the status of household food security and its determinants. That was followed by the discussion about the impact of adaptation on household food security and level of sesame production under chapter five. Finally, chapter six presented a synthesis of the main results of the previous chapters and described scientific insights and implications for climate hazard management through adaptations and issues for further research.

Chapter Two

2. DETERMINANTS OF SMALLHOLDERS' EXPORT-POTENTIAL CASH CROP PRODUCTION DECISION IN ETHIOPIA: THE CASE OF SESAME SECTOR

Abstract

Though Ethiopia is one of the main sesame producing countries in the world, studies revealed that Ethiopia's sesame sector is performing by far below its full potential. This study examined the factors that impacted smallholders' sesame production participation decision and level of their production in the western part of Ethiopia using cross-sectional data collected from 400 sampled households. The study employed double-hurdle model to empirically identified factors affecting households' separate decision making process regarding sesame production participation (using probit model) and level of production (using truncated model). The result indicated that sesame production decision is significantly constrained by farmers' resource endowment and market information. Smallholders with more education, land, food availability and credit access are more likely to plant sesame and among producers the level of production is also positively and significantly correlated with number of oxen, family access to food for the whole year, access to credit and off-farm activities, access to market price information and selling channel. The direction of influence and significance level of some of the explanatory variables vary between the two stages of production decisions. Consequently, it is imperative to devise a policy that enhances farmers' food security in cash crop potential areas so as to enable them to fully engage in production of market oriented cash crop. Interventions that promotes farmers' access to credit, alternative income earning sources, and establishing updated sesame market price information flow and appropriate selling channels would be of paramount importance in commercializing and shifting rural farming in to market-oriented and export potential high value crops like sesame.

Key words: Sesame production, determinants, double-hurdle model, Ethiopia

2.1 Introduction

Except Africa, all developing regions of the world have achieved the Millennium Development Goal of reducing poverty by half between 1990 and 2015 (UN2015). Since most of Africa's poor depend largely on rain-fed agriculture for their livelihoods (IFAD2011), improving the productivity of the agricultural sector is argued to be the main path way out of poverty in the continent (Christiaensenetal.2011; Asfawetal.2012; Dawson etal.2016). In spite of this fact agricultural sector growth in Africa has been lagging (Diaoetal.2012). Particularly the agricultural productivity in SSA remains stagnant (Tittonell and Giller2013). Over the past four decades, agricultural productivity growth in SSA averaged only 2.4% while the productivity of the rest of the developing world improved by 4% (Dzankuetal. 2015).

Like many SSA countries, the growth in agriculture holds the key to the economic growth and development of Ethiopia. About 85%ofitspopulationlivein rural areas and depend on agriculture for necessities and as a source of employment (Negatuetal.2016). Ethiopia's agricultural sector has recorded remarkable rapid growth in the last decade and was also the major driver of poverty reduction (WB, 2015d). The sector is also dominated by smallholders where about 12 million smallholders farming households account for an estimated 95 percent of agricultural production and 85 percent of all employment creation (FAO, 2015). Therefore, the performance of this sector largely determines the fate of the economy of the country.

Crop production constitutes a major share in agricultural production and accounted for 31.5 percent of GDP in 2011 and 30.4 percent in 2012. Thus, increasing crop production enhances agricultural output in particular and the gross domestic product in general, and is essential to improve the income and living conditions of the majority of citizens (FAO, 2015). Oilseeds, one among high value crop, are the mainstay of the rural and national economy in Ethiopia since they are the second largest foreign currency earner for the country after coffee and already more than 3.7 million smallholders are earning their living from oilseeds production (CSA, 2014). One of the major oilseeds, which become a focus of this study, for which Ethiopia is known in the international market, is sesame. In 2014, sesame production is dominated by more than 867, 347 small-scale farmers cultivating a total of 420,495 hectares of land (CSA, 2014).

Study shows, sesame production has grown tremendously over the 2000-2012 period (see appendix II), at an annual average growth rate of 34 percent (FAO, 2015) and reached its maximum in 2010. The total area harvested increased by more than 900 percent between 2000 and 2010. It reached a peak of 384,680 ha in 2010, before decreasing to 239,532 ha in 2012 and then rose to new peak in 2014. The averaged growth over the 2005-2012 periods was about 76 percent (FAO, 2015). Yields went from 0.4 tonnes/ha in 2000 to 1.0 tonnes/ha in 2008, finally reaching almost 0.8 tonnes/ha in 2012. The decrease was of -10 percent from 2005 to 2012 (FAOSTAT, 2013 quoted in FAO, 2015). Although there was an increase in average yields from 2000 to 2012, they are still considered low compared to the full potential sesame production (CSA, 2018) (see appendix III).

The close analyses of the sesame scenario over the periods of 2010-2016 (see appendix IV) shows that yield remain constant at 0.75 tonnes per hectare. Both production and area allocation declined from the peak of 2010 to the minimum in 2012. Then hectares of land rises to another highest point in 2014 before it decline then after. Though production rises after 2012 it didn't return back to the highest production level achieved in 2010 but rather start declining after 2014. Over 2010-2016 periods average production growth rate declines by -35 percent while the average growth rate of total area harvested was declined by -29.3 percents. Similarly, households involved in sesame production has decline by -18 percent in 2016 from the peak of 894 thousand households in 2011.

Though, Ethiopia is one of the major sesame producing countries in the world, ranking 5th in production until 2010 (FAO, 2015),it gave way its rank to Tanzania in since 2011 because of mainly decline in area of production and consequently production (ATA, 2015). The achieved growth in production was mainly explained by extension and there was an increase in average yields from 2000 to 2012 (FAO, 2015). Despite the country's immense potential to increase its production and productivity; government policy support to promote commercial agriculture and significant increase in international demand for sesame, studies shows that a number of challenges hampered the development of sesame sector (ATA, 2015) and consequently Ethiopia's sesame sector is performing below its full potential (FAO, 2015).

In order to harness the country's high sesame production potential and meet rapidly growing international market demand for Ethiopian Sesame the Ethiopian Agricultural Transformation Agency (ATA) in collaboration with the Ministry of Agriculture (MoA) and other key stakeholders has developed an integrated national strategy for the sesame sector-Sesame Value Chain Development Strategy (2015-2020). The strategy comes to the conclusion that Ethiopia's sesame sector is performing below its full potential due to various challenges. Some of the major bottlenecks are: (1) improved seed varieties are not effectively developed, produced and distributed, (2) agronomic practices are not effectively researched and disseminated to farmers, and (3) cooperatives do not have the capacity to meet input and output demand of farmers. In order to address the bottlenecks, many interventions have been identified along the sesame value chain among which are undertaking systematic study on socio-economic aspects such as production constraints and opportunities, gender roles and marketing of sesame (ATA, 2015).

There is, however, little knowledge about the determinants of smallholders' sesame production decision and their level of production participation. Studies on Ethiopian sesame sector are all most all dominated by sesame sector value chain analysis which indicates that both production and marketing of sesame are hampered by many constraints. The main constraints are: low use of improved seeds, fertilizers and cultivars; biotic stress and lack of knowledge on adequate post-harvest crop management; poor improved inputs supply system and insufficient extension services; and little research support to increase yields (ATA, 2015; FAO, 2015, Meijerink, 2014, Coates et al., 2011, SID-Consult, 2010, Sorsa, 2009, Wijnands et al., 2007). These studies, further, indicates that sesame face marketing constraints and hence losing opportunities of gaining high prices due to poor sesame quality, poor organization of sesame value chain, and underdeveloped market information system.

Further, most of the studies have assessed the general production and trade set up of the sesame sector by mainly focusing on the marketing aspects of the crops. By focusing on the common sesame production and marketing related problems which are mainly external to the individual farm households, the previous studies overlooked factors affecting the production, productivity and marketing decisions at individual household levels. Methodologically, they relied on general descriptive assessment and small sample size rather than rigorous statistic and

econometric analysis. Yet, it is going to be invaluable to identify and analyze household specific factors which are hampering households from participating in sesame production to achieve highest level of production. This needs robust analysis by identifying specific agro-ecologically feasible areas for growing sesame.

Given this, this study aims to address the following research questions: what are the main factors influencing and determining smallholder farmers' decision to participate in sesame production and level of sesame production? Thus, it is intended to analyze household specific factors influencing smallholders' production decisions and level of sesame production participation in East Wellega Zone for the production period of 2017. The general objective of the study is to analyze the production decision and performance of smallholder sesame production. Specifically, we intended to: analyze the factors influencing farmers' decision to participate in sesame production and examine the determinants of the level of sesame production.

An investigation of farm-and crop-specific production constraints and the underlying determinants may greatly help local and regional governments. This is particularly important to inform policy makers in identifying the main factors which affects farmers' decision to take part in sesame production and their level of production participation. Therefore, a thorough study on these issues may help to identify the production constraints at farm level and there by develop policy recommendations to increase sesame production and productivity so that it will contribute to the export earning and poverty reduction efforts. This study, thus, aims to contribute towards a better understanding of main factors affecting sesame sectors production decisions and levels of production in Western Ethiopia.

2.2 Definition of Concepts

In literatures, diversification of agriculture is explained as developing a large number of crops or enterprises-mix. It is mainly done as a response of subsistence farmers to reduce risks arising from climatic, biotic, or seasonal factors (Francesco, 1999). Narrowly defined, agricultural diversification implies increasing the variety of agricultural commodities produced at the farm level. While, a broader explanation agricultural diversification is a process accompanying economic growth, characterized by a gradual movement of resources out of subsistence of

food crops to a diversified market oriented production system. This is mostly initiated by improved rural infrastructure and rapid technological change in agricultural production-particularly staple food production (Rosegrant and Hazell, 1999). Broadly defined, agricultural diversification involves the entire rural economy and entails broadening the income sources of rural households. The process involves not only cropping, but also new marketing and agro-food based industrial activities that affect the overall rural economy (Goletti et al., 1998; Francesco, 1999).

Moreover, the concepts of diversification can also be applied to crop level in a given farm. Crop diversification is regarded as the re-allocation of some of a farm's productive resources, such as land, capital, labor, and farm equipment, into new farm activities. In other words, crop diversification helps for proper utilization of agricultural resources through providing the farmers with viable options to grow different crops on their land. Therefore, farmer's decision to diversify is considered a major economic decision that has a strong bearing on the farmer's income level and food security (Ashfaq et al., 2008; Poudel et al., 2012; Sichoongwe et al., 2014).The application of concept of diversification in empirical studies, therefore, requires making distinction between broader and narrower definition of agricultural diversification. Therefore, crop diversification can be defined in this study within the narrower definition of agricultural diversification, defined in terms of growing many crops at the same time on the same plot to minimize risk and uncertainty due to market fluctuations, climatic and biological vagaries.

2.3 Theoretical Framework

The supply of agricultural commodities (food crops or cash crops) to local, national, regional or international markets depend upon the activities of large numbers of farm households. These farm households choose to produce food crops for home consumption or cash crops for market, based on the available comparative advantages from production of these crops. In the basic agricultural household model[1], households chose the level of land (l) and capital (k) to invest in the production of staples (ps) and cash crops (pc). Then it is assumed that, these choices are

[1]The theoretical model presented and used in the present study is adopted from Henderson et al., 2010 with some modifications. And this model is based on the period of one production year with the assumption that the production year starts just prior to planting (Henderson et al., 2010).

made to maximize utility from consumption of staple crops(C), leisure (L) and all other goods purchased in the market (M). With this established the household optimization problem becomes maximizing utility subject to a list of constraints and can be specified as:

$$U = U(C, M, L)\ldots\ldots 1$$

This utility maximization objective is assumed to be constrained by the prevailing production technology constraints, resource (time, land, capital, labor, others) allocation constraints and cash income constraints. Production technology constraint is basically assumed to describe the link between input and output, by considering other production shifters. Mathematically, one can represent the production technology constraint as follows:

$$Q = Q(q, n, Zq)\ldots\ldots 2$$

where q-is quantity of farm produce, n-is the production input which is relevant in specific crop production including land, labor, capital, time, etc and Zq describes unknown shocks to production, but reveled to farmers after production decisions are made.

Similarly, the cash income constraint states that the income from sales of farm produce (i.e. from sale of cash crops or surplus staple crops and from livestock productions), plus off-farm work minus the costs of purchased variable inputs cannot exceed the sum of available cash for purchase of consumer goods, production inputs and other household expenditures.

Mathematically, this relationship can be specified as follows:

$$pC + mM + wL = wL + R + \Pi = Y \ldots\ldots 3$$

where: p- represents price of home produced goods, m –price of purchased consumer goods, w – labor price(wage), Y –describes the full income from farm profit together with total value of off-farm incomes and transfers (R).

After all, maximization of household utility subject to these constraints can be solved by maximizing the corresponding lagrangian function; and the optimal production decision can be derived by differentiating this lagrangian function with respect to each specific variables. The point here is just to select the optimal production decision to maximize the stated utility

maximization objective. This requires, linking these two decision problems together and the finding the optimal utility level from production decision. In cash crop productions farm households can be treated as a commercial firm, hence it was assumed that the intention to produce such crop was to sell all of the output produced to the market, with a single objective of maximizing profit. Thus, one can apply the recursive model and identify what factors determine smallholder farmer's participation in to these cash cropping.

Hence the objective of the current study was to identify what factors determine the production participation decisions and level of production participation of smallholder farmers in one of the cash crops (sesame).This model tries to link production decision and utility maximization problems together. To do so, we assume that farmers decide on input demand (i.e. production decision); by considering the expected comparative advantages from participation in the activity which will be compared with respect to the other alternatives.

With this principle, we turn to the first stage production decision specification as follows. For this purpose a reduced production technology equation was assumed, and the quantity of output produced was considered as already given. Then the decision rule for production participation can be defined as:

$$Q = f(q, n, Zq, Xi) \quad \ldots\ldots 4$$

$$Pi = 1 \text{ if } q > 0, \text{ and } Pi = 0 \text{ if } q = 0$$

where Pi - is the binary indicator, indicating whether the farmers decide to produce the specific crop and Xi are vectors of factors relevant in crop production processes. In addition, as the focus of the current study was to also analyze factors affecting the level of crop output produced, the binary indicator of the empirical model would include these both issues (production participation and the level of participation decision issues).

2.4 Methodology

2.4.1 Methods of data analysis

Sesame production participation (Probit Model)

Different methods can be used to analyze the above discussed farm household decision problem. One approach to analyze the issue is to use the well-known Tobit model. However, Tobit model assumes that both the decision to participate in activity and the level of participation are determined by the same variables and with the same sign (Wooldridge, 2002). It mean the decision to participate in production of a certain crop and the level of production participation are jointly determined and influenced by the same parameters. This restriction of variables and coefficients in the two decisions (production participation and level of participation decisions) to the same sign and significance is the main drawback of Tobit model (Wooldridge, 2002). That is why recent empirical studies have shown the inadequacy of the Tobit model in cross-sectional analysis, stressing the relevance of alternative approaches.

In this regard, one alternative approach is to employ the Heckman two step procedures. According to this model the decision to produce a crop and the level of production participation may not necessarily be jointly determined (Humphreys, 2010). Yet, the Heckman selection model is appropriate if there is a censoring process in measuring the level of production participation. It means the model assumes there is some potential production levels in the sample population, but are not observed due to sample selection problem. This indicates Heckman's sample selection model was designed to account for the fact that the observed sample may be non-random. In our study, zeros in level of sesame production (the dependent variable in the second stage) was due to non participation in sesame production, hence not either due to corner solution (Tobit) or sample selection problem.

The recommended approach to be used in this case and applied to this study was the Double-Hurdle (D-H) model. This model assumes farmers faced with two hurdles in any agricultural decision making processes (Cragg, 1997; Sanchez, 2005; Humphreys, 2010). Accordingly, the decision to participate in an activity is made first and then the decision regarding the level of participation in the activity follows. In this study, thus, double-hurdle model has been chosen because it allows for the distinction between the determinants of production participation and the level of participation in sesame production through two separate stages. This model estimation procedure involves first running a probit regression to identify factors affecting the

decision to participate in the activity using all sample population. Secondly, a truncated regression model on the participating households to analyze the level of participation runs.

To derive the likelihood function, we begun in the first stage (production decision) where households are identified according to whether they are producers or not, using probit analysis. To do so, let Pi denote a binary indicator function taking value "1" if farmers participate in sesame production in 2017 production year and "0" otherwise. Further, let Li denote the land allocated to sesame produced in the specified production year. Then the likelihood function for the standard double hurdle model can be written as:

$$\ln L = \sum_{G1=1} \ln\left[\varphi \ \chi_1\gamma \times \left(\frac{1}{\sigma_u}\right) \times \phi\left(\frac{Y - \chi_2\beta}{\sigma_u}\right)\right]$$
$$+\sum_{G2=1} \ln\left[\varphi \ \chi_2\beta/\sigma_u \times 1-\phi \ \chi_1\gamma \ \right] + \sum_{G3=1} \ln\left[1-\varphi \ \chi_2\beta/\sigma_u \ \right] \quad \ldots\ldots\ldots 5$$

where φ and φ are the probability density and cumulative distribution function of the standard normal variable, respectively; G1, G2, and G3 are indicator functions showing whether a given observation belongs to group one, two, or three, respectively: households producing sesame, households wanting to produce but reporting zero production, and households choosing not to produce. Equation (5) can be estimated using maximum likelihood (ML) techniques, which will give consistent estimates of the parameters. If ui and ei are independent, the ML function can be separated into a probit and a truncated normal regression model.

Based on the above backgrounds, the linear probit model can be specified as the follows: $P\ Y_i = 1\ = \beta_0 + \beta_i X_i + \varepsilon$ where P is the probability of an individual farm household to participate in sesame production, βi is the vector of parameters to be estimated, Xi is the vector of exogenous explanatory variables expected to influence the participation decision probability and ε is the error term.

The reduced functional relationship between the binary dependent variable (producing sesame or not) and a list of explanatory variables for the empirical analysis can be specified as follows using basic probit model specification: $\Pr\ P\ = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_{14} X_{14i} + \varepsilon_i$

where Pr is the probability at which an individual household participate in sesame production represented by (P=1), βi's – are the coefficients to be estimated and εi –is the error term. The list of X_{1i} to X_{14i} are the vector of exogenous explanatory variables listed under Table 1 below.

To assess the impact of the regressors on the dependent variable, it was necessary to analyze their marginal effects. This involves decomposing the unconditional mean into the effect on the probability of producing sesame and the effect on the conditional level of production participation and differentiating these components with respect to each explanatory variable. For the continuous explanatory variables, these marginal effects give partial effects of these variables at the sample means. While for the discrete or categorical variables, the marginal effects are used to calculate percentage changes in the dependent variable when the variable shifts from zero to one, ceteris paribus (Newman et al., 2003).

Level of Sesame production participation (Truncated Model)

In the second stage of double-hurdle model we examined factors affecting the level of sesame production, conditional on participation decision, which was implemented using the truncated regression analysis. Thus, it involves the truncated regression that can be specified as:

$L = L^{*}$ if $L^{*} > 0$ and $Y = 1$

$L = 0$ otherwise

From this, we can specify the reduced form of the truncation model as: $L = \beta_0 + \beta_i Z_i + \upsilon_i$

where L is the size of land allocated to sesame production in hectare, L* is the latent variable which indicates the land size is greater than zero, βi is the vector of parameters to be estimated, Zi is the vector of exogenous explanatory variables and υ_i is the error term. The empirical model used in this study assumes that the total land allocated for sesame produced was a linear function of continuous and dummy explanatory variables and is specified as follows:

$$L = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + ... + \beta_{16} X_{16i} + \upsilon_i$$

where L is the size of land allocated to sesame production in hectare in 2017 production year, βi's – are the coefficients to be estimated and υ_i is the error term. The lists of X1i to X16i were the vector of exogenous explanatory variables given under Table 1 below.

Statistical and Specification Tests

Before executing the final model regressions, all the hypothesized explanatory variables were checked for the existence of statistical problems such as multicollinearity problems. Among many methods, Variance-Inflating Factor (VIF) technique is commonly used to detect multicollinearity problem among continuous explanatory variables (Gujarati, 2004). Mathematically, VIF for individual explanatory variable (Xi) can be computed as: VIF (Xi) = 1/(1-R2) where R2 is the coefficient of correlation among explanatory variables. According to Gujarati (2004), the larger the value of VIF indicates the more collinearity among one or more model explanatory variables. As a rule of thumb, if the VIF of a variable exceeds 10, which will happen if a multiple R-square exceeds 0.90, that variable is said be highly collinear. Similarly, Contingency Coefficient (CC) method was used to detect the degree of association among discrete explanatory variables (Healy, 1984). According to Healy (1984), the discrete/dummy variables are said to be collinear if the value of contingency coefficient (CC) is greater than 0.75. Mathematically: $CC = \sqrt{\frac{X_2}{n + X_2}}$ where CC- is contingency coefficient, n- is sample size, X2-is chi square value.

Finally, the Double Hurdle model can be tested against the Tobit model using a standard likelihood ratio test, as the Tobit model is nested in the double hurdle model (Humphreys, 2010). Practically, whether a Tobit or a double hurdle model is more appropriate can be determined by separately running a log likelihood ratio test that compares the Tobit with the sum of the log likelihood functions of the Probit and truncated regression models (Berhanu and Switon, 2003). The log-likelihood of the D-H model is the sum of the log-likelihood from a probit model and the truncated regression model (Adam et al., 2011).

$LR = -2[LogL_T - (LogL_P + LogL_{TR})] \sim \chi^2_k$ where $LogL_T$ is log-likelihood for the Tobit model, $LogL_P$ is log-likelihood for the Probit model, $LogL_{TR}$ is log likelihood ratio for the Truncated

model and k is the number of independent variables in the equations. The test statistic has a Chi-square distribution with degrees of freedom equal to the number of independent variables.

2.4.2 Definitions variables and hypothesis

The first dependent variable in this study was production participation, which is a dichotomous variable taking the value 1 if the household participates in sesame production and 0, otherwise. This lets us to analyze the main determinants of households' sesame production participation decision using the probit regression. The second dependent variable was the size of land allocated for sesame production in hectare in the specified production year 2017. We employ this variable to capture, after the household decide to produce sesame, the factors that influence the level of sesame produced participation by using truncated regression. As presented in table 1 below, we have had included personal, household, socioeconomic, crop-specific, institutional, marketing and geographic location variables in our analysis. The selection of those variables were guided by previous empirical literature (e.g. Weiss, C & Briglauer 2000; Mishra & El-Osta 2002; Ashfaq et al. 2008; Burke 2009; Fetien et al. 2009; FAO, 2012; Wondimagegn et al. 2011; Sichoongwe, 2014).

It is expected that as age, one among the personal characteristics of the household, increases farmers would acquire knowledge and experience through continuous learning which help them to actively participating in production of market-oriented cash crops. On contrary, previous study indicated that elderly farmers look at farming as just a way of life while young farmers look at farming as a business opportunity for family sustenance (Mishra and El-Osta 2002; Ashfaq et al. 2008; FAO, 2012; Sichoongwe, 2014). Previous study also showed that sex has a positive effect on diversification (Fetien et al. 2009; Wondimagegn et al. 2011). They indicated that male-headed households are more likely to participate in sesame production than female-headed households. Education of the household head is another personal character which can positively affect farmers' participation in market oriented crop diversifications (Ibrahim et al. 2009; Sichoongwe, 2014). Similarly, the larger the household size (active family labor), the more likely that it will able diversify from food crop to cash crops (Weiss, C & Briglauer 2000; Benin etal. 2004; Wondimagegn et al., 2011).

Previous studies also showed that the farmers land holding size is another variable which has a positive and significant relationship with agricultural production participation (Wondimagegn, et al. 2011; Poudel et al. 2012). Access to off-farm activities is another variable which can have either of the two effect on farmers sesame production participation and level of production. Mishra & El-Osta (2002); Weiss & Briglauer (2000) have reported negative effect. Among the off-farm activities are the annual income farmers earn from selling livestock. Study by Wondimagegn,et al. 2011 also indicated that off-farm income source negatively impacted farmers' farm involvement. Another important economic factor which expected to highly influence farmers shift to cash crop production is the availability of (access to) family food the whole year. It is always argued that smallholder farmers in developing countries participate in production of cash crops only if they could produce enough of family foods. Thus, if farmers have potential and experience in producing sufficient family food for the whole year, it is expected that they are more likely to participate in production of cash crops such as sesame.

Table 1: Description of explanatory variables and hypotheses

Description of explanatory variables and hypotheses		
	Description	**Expected Effect**
Dependent variable		
Producers	Sesame production participation decision; 1 if household head participated in sesame production and 0 otherwise	
Land Sesame	Land allocated for sesame cultivation in hectare	
Independent Variables		
Age	Age of household head	"+", "–"
Sex	Gender of the household head; 1 if male and 0 otherwise	"+", "–"
Education	Educational status of household head; years of formal schooling and 0 if not attended	"+"
Active family labor (AE)	Family labor force in Adult equivalent	"+", "–"
Numbers of Oxen	Number of oxen the household owned	"+"
Land total	Size of total land owned by the household in hectare	"+"
Income livestock	Annual income the household head earned from Livestock sell	"+", "–"
Year Sesame	Number of years since the household head started Sesame production	"+"
Credit access	Access to credit for Sesame production; 1 if the household head has access 0 otherwise	"+"

Coop membership	Cooperative membership; 1 if the household head is member 0 otherwise	"+"
Farm Extension	Access to farm extension (FTC)	"+"
Income nonfarm	Participation in off/nonfarm activity; 1 if the head earn income by participating in off/nonfarm activities and 0 otherwise	"–"
Food availability	Availability of food all over the year; 1 if the household head has food available the whole year 0 otherwise	"+"
Access price info	Access to market price information; 1 if the household head has access 0 otherwise	"+"
Selling channels	Sesame selling channels; 1 if sold directly and 0 if sold via brokers	"+", "–"
Distance extension	Distance from the respondent's residence to the farm extension center measured in kilometer	"–"
Distance market	Distance from the respondent's residence to the nearest market measured in kilometer	"–"

It is expected that farmers' who have participated in production of sesame for long years will have good experience on its production and likely to produce more amount in the survey year. With regard to the institutional determinants, farmers' access to credit is the main one. Those who have more access to credit service are expected to produce market oriented cash crops like sesame. As also revealed by Bruke, 2009, credit prevalence is an important determinant factor in all stages of the farmer's production and marketing decisions. It is hypothesized that access to price information positively affects the income earned from sesame sale and then level of sesame production. We hypothesized that the existence of middle men in the selling channel will negatively affect farmers' earning and then their level of production. Further, distance from the extension service center is one of the geo-graphical factors which can impact farmers' production behavior. According to Wondimagegn et al., 2011 finding, the larger the number of contacts a farmer has with an extension agent, the more he is likely to engage in production of large number of enterprises. The finding of Fetien et al. (2009) also supported this hypothesis. The same analogy also works for farmers' distance from the nearest market center.

2.5 Results and Discussion

Descriptive statistics

Tables 2 and 3 present the summary statistics for dummy and continuous variables. As observed in the table, about 93% were male-headed household. Age of the total sample respondents

ranged from 18 to 80 years with a mean of about 41 years. On average, the sample respondents have been engaged in farming for 11 years and about 23% of the sample household heads did not attain formal schooling. The mean family size of the sample households measured in adult equivalent (AE)[2] was 7.1. On average, sample respondents have 3.2 children who are aged less than 16 years. On average, respondents own 1.96 oxen and they own 4.26 units of livestock measured in Tropical Livestock Unit (TLU) which is equivalent with 0.81 TLU per adult equivalent. The size of total land owned by the sample respondents ranged from 0.25 to 24 hectare while an average size is 3.81 hectare. Nearly half of the total respondents have an access to any form of credit, 66% of them are cooperative membership and 24% of respondents are engaged in off farm activities. Out of the total of the respondents, 68% have access to market information and 85% of them sell their products directly without brokers in between. Sixty percent of the total respondents have access to food availability the whole year and 59% of them have access to farm extension services. The sample respondents are, on average, 2.42 and 2.26 km far from the market and farmers training center, respectively.

The summary statistics presented under Table 2 and 3 are also helpful to observe the characteristic differences between sesame producers and non-producers households. The chi-square analysis shows that larger proportion of sesame producer households are members of cooperatives; have access to market price information and have food available for the whole year. The result further indicates that greater proportions of sesame producer households are male-headed households, accessible to extension advisory services and credit and has no off farm activities, as compared to their counterparts. The independent t-test result shows that there is a significant mean difference between sesame producer and non-producer households with respect to education, active family labor force and size of total land owned.

Table 2: Association between determinants (discrete variables) of sesame production decisions

Variables	Categories	Producers (n)	Non Producers (n)	Chi-Square Value
Sex	Female	24	5	22.140***
Credit access	Yes	153	46	8.341***
Coopmembership	Yes	189	65	5.761***

[2]Family size is calculated by converting difference in age and sex of members of the family members using the conversion factor given tables in Appendix II, and III, respectively, indicates the conversion factor used to compute TLU.

Farm extension	Yes	173	62	3.090*
Income nonfarm	Yes	60	35	2.999*
Food availability	Yes	251	66	10.431**
Access price info	Yes	195	76	1.170^{ns}
Selling channels	Via brokers	150	99	31.764*

***, **, * and ns significant at 1%, 5%, 10% and not significant respectively

Table 3: Association between determinants (continuous variables) of sesame production decision

	Producers		Non Producers		
	Mean	**SD**	**Mean**	**SD**	**t-value**
Age	41.539	12.093	41.313	10.375	0.188^{ns}
Education	4.555	3.575	4.008	3.567	3.399***
Active family labor(AE)	9.21	3.676	4.886	4.241	10.313***
Numbers of Oxen	2.103	1.526	1.807	1.58	1.758*
Land total	4.410	2.959	3.209	2.523	3.863***
Year Sesame	10.934	7.393	11.437	8.503	-0.594^{ns}
Income livestock	7.244	8.030	6.847	8.124	2.451**
Distance extension	2.285	4.251	2.229	2.930	0.131^{ns}
Distance market	2.506	2.092	2.323	2.047	0.608^{ns}

***, **, * and ns significant at 1%, 5%, 10% and not significant respectively

Econometric Analysis

Model Specification Test

The Log-Likelihood result (see Table 4) rejects the null hypothesis that the Tobit model is appropriate and indicates that the estimated D-H model is preferred. The test statistics for the log likelihood is 298.775 which by far exceed the critical chi-square value of 32.000 at 17 degrees of freedom and at a less than one percent level of significance in favor of the D-H model. This shows the existence of two separate decision making stages during the adoption process. This result provides an empirical result of households' independent decision making regarding the sesame production participation decision and level of production in the study areas.

In this regard, the estimated results for D-H model shows some variables appearing in both equations have opposite influences in terms of both sign and level of significance. For instance, access to non-farm activities, distance from extension and distance from market have conflicting

signs in production participation decision and level of production equation. Similarly, distance from extension is insignificant explaining the level of production equation but significant in production participation decision equation. These results disprove the Tobit model assumption that restricts variables and coefficients in the two decisions (production participation and the level of participation decisions) to the same sign and significance (Wooldridge, 2002).D-H model is widely applicable since it relaxes this restriction of Tobit model. Unlike Tobit model, D-H model has not only advantage of showing different signs and effect but also enables us to use different variables for the production participation decision and level of production equation. For instance, we have included four additional variables namely years of sesame, access to price information and selling channels in level of production equation which are not in production participation decision equation.

Table 4: Test Statistics of Double Hurdle Model against Tobit Model

Test Statistics	Probit regression	Truncated regression	Tobit regression
Chi2(16)	152.14***	26.98**	214.59***
Log-L	-61.70	-214.61	-425.70
Number of observations (N)	250	281	400
AIC(-Log-L+k)/N	0.31	0.82	1.10
	Log-Statistics	298.775***	X2(16)=32.000

Model output, *, **, *** significant at 10%, 5% and 1%, respectively

2.5.1 Determinants of sesame production participation decision (Probit Regression)

A probit model was used to identify potential explanatory variables affecting household's sesame production participation decision. Before running the analysis, multicollinearity was checked using VIF for continuous variables and CC for dummy variables. The calculated VIF values are all less than 10 (the cut-off point) and CC were less than 0.75 (the cut-off point) which indicated that multicollinearity is not a serious problem (see Appendix VII and VIII). Among 14 variables fitted into the model, education, land total, credit access, income nonfarm, food availability and distance extension are found to be significant at less than 5% of significance in determining production participation decision of the household. The influence of all the significant variables is in the expected direction. Table 5 below provided the parameter estimates and average marginal effect, respectively, of the probit model results.

As expected, the education level of household head has a positive and significant ($p<0.05$) relationship with the probability of sesame production participation. Average marginal effect of education indicates that for each additional year of education, households are 1.4% more likely to participate in sesame production. The result is plausible as household with exposure to some levels of education tends to have greater access to production and market information, hence expected to produce market oriented cash crops like sesame. Likewise, Govereh & Jayne (2003) found that education level of the household is the most critical determinants of smallholder decision to produce cotton in Zimbabwe. The size of total land owned by household impacted the probability of decision to participated in sesame production positively and significantly ($p<0.01$). This is reasonable, because larger farms are not only wealthier but also have a higher capacity to expand agricultural production that in turn enables them to produce more cash crops. The result is consistent with the findings of Poulton et al. 2001 who suggests that land is an important factor in influencing farmer's decision to produce any cash crop.

Availability of food all over the year for the family has influenced the households' probability to participate in sesame production positively and significantly ($P<0.05$) where household with access to food the whole year is 11.2% more likely to participate in sesame production in comparison with those who didn't have food available all over the year. This is plausible because farmers first want to secure foods for their family and participate in cash crop production only if farmers have potential and experience in producing sufficient family food for the whole year. This is in line with Jayne, T. (1994), who attests that food security condition is the one possible factor in limiting smallholder farmers' cash crops production. Access to off farm activities was found to have negative and significant ($P<0.05$) impact on probability of participating in sesame production. This can be explained by the fact that if the farmers have access to alternative income generating activities to farm income they less likely to participate in sesame production.

Table 5:Probit regression of factors determining the probability of Sesame Production

Producers	Coef.	St.Err	Z-value	Marginal Effects
Sex	0.125	0.352	0.35	0.038
Age	-0.004	0.007	-0.56	-0.001

Education	0.045	0.022	2.02**	0.014
Active family labor(AE)	0.048	0.033	1.46	0.015
Numbers of Oxen	0.073	0.054	1.35	0.022
Land total	0.100	0.031	3.19***	0.031
Income livestock	-0.056	0.094	-0.59	-0.017
Credit access	0.407	0.150	2.72***	0.125
Coop membership	0.266	0.175	1.51	0.082
Farm extension	0.171	0.150	1.14	0.053
Income nonfarm	-0.429	0.169	-2.53**	-0.131
Food availability	0.365	0.178	2.05**	0.112
Distance extension	-0.041	0.017	-2.38**	-0.013
Distance market	0.048	0.030	1.60	0.015
_cons	-0.795	0.507	-1.57	0.038

Mean dependent var	0.702	SD dependent var	0.458
Pseudo r-squared	0.115	Number of obs	399.000
Chi-square	55.770	Prob > chi2	0.000
Akaike crit. (AIC)	460.508	Bayesian crit.(BIC)	520.342

*** p<0.01, ** p<0.05, * p<0.1

In agreement with a prior assumption, access to credit for sesame production has a positive and significant (p<0.01) effect on the probability of sesame production participation. The household who has access to credit for sesame production is 12.5% more likely to participate in sesame production than those who has no access. This suggests farmers' access to credit for sesame production has paramount importance in letting them to participate in production by financing agricultural inputs like improved seed and fertilizers. In line with our result, the finding by Burke, 2009 also suggests that credit prevalence is an important determinant factor in all stages of the farmer's production and marketing decisions. This finding is also confirmed in study by Lukanu et al. (2004).

2.5.2 Determinants of Intensity of Sesame production (Truncated Regression)

A truncated model was used to identify potential explanatory variables affecting household's sesame production level captured via size of land allocated to sesame production. Before running the analysis, variables assumed to have an influence on level production were tested for multicollinearity and degree of association among variables using VIF and CC, respectively. The test results show that there is no multicollinearity and series association problem among the variables. Among 16 variables fitted into the model, sex and number of oxen owned, land total, food availability, credit access, access to price information and non-farm income are significant

at less than 5% while education, and selling channels are found to be significant at less than 10% of significance in determining intensity of sesame production by the household. The influence of all the significant variables is in the expected direction except for year of sesame farming. Table 6 below provided the parameter estimates and average marginal effect, respectively, of the truncated model results.

In agreement with prior expectation, sex of the household head influenced level of sesame production positively and significantly. This is probable due to the fact that male household heads have more exposure and access to new information and interventions than female household heads. Likewise, the education level of household head has a positive and significant ($p<0.1$) relationship with the level of sesame production. The result is plausible as household with exposure to some levels of education tends to have greater access to production and market information, hence expected to produce intensify market-oriented cash crops like sesame.

Table 6: Truncated Regression of determinants of level of sesame production

Land Sesame	**Coef.**	**St.Err**	**z-value**	**Marginal Effects**
Sex	1.649	0.631	2.61***	0.383
Education	0.103	0.060	1.73*	0.024
Active family labor (AE)	0.074	0.054	1.38	0.017
Number of Oxen	0.325	0.117	2.78***	0.076
Land total	0.114	0.058	1.96**	0.026
Year Sesame	-0.045	0.028	-1.56	-0.010
Income livestock	-0.042	0.030	-1.41	-0.010
Food availability	1.045	0.500	2.09**	0.243
Credit access	0.994	0.438	2.27**	0.231
Coop membership	0.716	0.556	1.29	0.166
Access price info	1.062	0.503	2.11**	0.247
Farm extension	0.464	0.428	1.09	0.108
Income non-farm	0.948	0.446	2.13**	0.220
Selling channels	-1.274	0.707	-1.80*	-0.296
Distance extension	0.049	0.044	1.12	0.011
Distance market	-0.088	0.074	-1.19	-0.020
_cons	-7.065	2.276	-3.10***	
/sigma	1.525	0.215	7.10***	
Mean dependent var	0.902	SD dependent var		0.914
Number of obs	281.000	Chi-square		26.983
Prob > chi2	0.042	Akaike crit. (AIC)		465.213
*** p<0.01, ** p<0.05, * p<0.1				

As hypothesized, number of oxen owned by the household has a positively and significantly affect the level of sesame production participation, where the household with one more oxen brings 0.076more hectares of land in to sesame produced. Since an ox is the most important means of land cultivation and asset in poor rural areas in Ethiopia, the number of oxen available to the household positively enhances the level of crop production. The size of total land owned by household impacted the level of sesame production positively and significantly. This is reasonable, because larger farms are not only wealthier but also have a higher capacity to expand agricultural production that in turn enables them to produce more cash crops. Edriss and Simtowe (2002) also show that the increment of land allocation to crops increases production and outputs.

Availability of food all over the year for the family was found to have positive and significant impact on the households' level of sesame production where household with access to food the whole year have additional 0.243 hectares of land in sesame production in contrast to those family who don't have enough food. Similarly, Boughton et al (2007) argued that the main challenge and constraint factor for smallholder farmers' to participate in cash crop production is the low productivity in food crop production and its market failure. Access to off farm activities has influenced positively and significant ($P<0.05$) the households' level of sesame production. This can be explained by the fact that if the farmers have access to alternative income generating activities which enable them to purchase more inputs they are more likely to participate in sesame production.

The regression result reveled that access to credit for sesame production is one of the determinant factor in influencing level of sesame produce positively and significantly ($p<0.05$). The household who has access to credit allocates 0.231 more hectares of land to sesame production than those who has no access. This suggests farmers' access to credit for sesame production the critical factor in determining level of sesame production participation. This is consistent with other study by Hassen et al., 2012. The FGDs held in the study area reveal that there are sesame traders who informally provide credit for farmers to specifically produce sesame.

Households access to market price information positively and significantly ($p<0.05$) impacted the level of sesame production. This result is in line with the finding of Cadot et al. 2006 who indicated that information communication facilities are the major determinants of participating in cash crop productions. The study by Alemu and W.Meijerink (2010) suggests that the presence of high transaction costs related, among others, to the lack of market information, the lack of trust among market actors and the lack of contract enforcement in Ethiopia at present. The regression result further provided that sesame selling channel has negative and significant effect on the level of sesame production. This shows that those households who sell sesame directly to the buyer allocate less land to sesame than those farmers who sell their output via brokers. This can be explained by the reason that since the broker may help farmers to sell sesame at higher price by connecting them to a potential buyer they would be encouraged to produce more sesame.

2.6 Conclusion and Policy Implication

This study analyzed the determinants that influence smallholders' probability of participating in sesame production--one cash crop that has export potential --and its production levels based on data collected from the western part of Ethiopia. Using the double-hurdle model, the study empirically identified the factors affecting farmers' decisions regarding participating in sesame production and their level of production. Our study proves that households' who have potential and experience in producing sufficient food for their families lead in intensifying sesame production. Farmers' access to credit for sesame production is a critical factor that helps determine the level of participation in sesame production. Though access to off-farm activities initially reduces farmers' probability of participating in sesame production, later it increases the size of the land allocated for sesame production. This possibly indicates that as farmers earn more from non-farm activities, there is a higher probability of their purchasing farm inputs and food for their families easily enabling them to intensify sesame production by allocating more land to it. The regression results show that farmers' access to price information and type of sesame selling channels they use have significant positive and negative effects on the level of sesame production respectively.

Based on the findings we make some recommendations for improving farmers' participation in the production of the market oriented cash crop sesame. To improve farmers' participation in the production of sesame, more emphasis should be given to insuring farmers' food security throughout the year. Farmers' participation in sesame production and their level of participation can also be improved by improving their access to sesame specific credit mainly from formal sources. The positive impact of access to off-farm activities on sesame production indicates that the government's efforts at diversifying rural livelihoods should be promoted to enhance commercialization of rural farming. Having observed the vital role that access to price information and getting proper sesame selling channels play, having effective sesame marketing systems in place will encourage households' to allocate more land to sesame production. In this regard, what is needed are interventions to solve input-output hurdles in the sesame market mainly through access to updated market price information and better selling channels. We also recommend a further study on a detailed sesame marketing system to identify marketing factors that work against the well-being of farmers.

Chapter Three

3. SMALLHOLDER SESAME PRODUCERS' ADAPTATION DECISIONS TO CLIMATE CHANGE AND ITS DETERMINANTS IN WESTERN ETHIOPIA

Abstract

The agricultural sector remains the main source of living for rural population in Ethiopia, but the challenge of changing climate continue to cause a severe danger to its development. This study examined factors influencing smallholder farmers' decisions to take adaptation measures to climate change in West Ethiopia using data collected from 400 sampled households. Rainfall Satisfaction Index and Multinomial Logit Model were used to analyze farmers' exposure to climate variability and factor that shape farmers' adaptation strategies. Our finding showed that majority of farmers' are experiencing high exposure to climate change both in terms of variable rainfall and rising temperature. In response, to adapt to the impact of climate change farmers' were take part in agronomic practices, livelihood diversification, soil and water conservation and small-scale irrigation as the dominant adaptation options. It is also observed that adopting agronomic practices was significantly impacted by social capital, frequency of drought occurrence and access to early climate warning. Gender of the household, education and livestock ownership was found to have negative relationship with livelihood diversification. The study additional indicated that soil and water conservation practices are positively influenced by perception of temperature increment, exposure to early warning systems, and farm size. Further, adoption of small-scale irrigation was significantly affected by household education status, credit access and social capital. Consequently, the result implies that programs and policies design to curb the calamities of climate change should give emphasis to creating effective early warning systems to increasing farmer awareness, reaching farmers' with effective microfinance institutions, and encouraging farmers' tie to many social cooperatives.

Keywords: Adoption, Adaptation options, Determinant, Climate change, MNL

3.1 Introduction

Scientific evidences revealed that the earth's climate is rapidly changing owing to increasing greenhouse gas emissions (Stern, 2006; Pachauri et al, 2014) which led to raising the average temperature and altered the amount and distribution of rainfall globally (Dasgupta et al, 2014; Solomon et al, 2007). In Africa, climate change has already placed a heavy burden on the dominantly rain-fed agricultural production (Bryan et al. 2009; Kahiluoto et al. 2012), and smallholder farmers livelihoods will be further threatened by ongoing climate change (Thornton et al. 2010). Limiting undesirable hazards of climate change has become a universal difficulty that makes the call for climate change adaptation and mitigation critical (McCarthy et al. 2011). In developing countries, so as to ensure the livelihoods of the poor communities, adaptation of the agricultural sector to the changing climate is very essential (Ngigi, 2009).

The Ethiopia rain-fed agriculture sector accounts for about 42.9% of GDP, 80% of employment, and 88% of export earnings (NBE, 2014). Despite its key role in the country economy, the sector is inherently sensitive and most vulnerable to climate change, characterized by a low use of external inputs (Conway & Schipper, 2011; Bewket, 2012; Robinson et al. 2013). A rising occurrence of droughts, floods, and volatile rainfall are the major indicators of the adverse impact of climate change (Ribot, 2010; Gizachew & Shimelis, 2014). This has resulted in recurrent food shortage and famine (Mersha & Boken, 2005; Gray & Mueller, 2012), and it is still posing a serious threat to Ethiopia's development (FAO, 2007).

In order to develop resilience to climate change-related risks farmers in developing nations has been practicing diverse adaptation strategies. Similarly, in Ethiopia, adaptation strategies to climate change have become one of the widely supported policy agenda (Stern, 2006; Kurukulasuriya & Mendelsohn, 2008). Farmers' perception about climate variability and a decision to use the selected adaptation strategies are influenced by a combination of different factors (Deressa et al. 2009; Schlenker et al. 2010). As climate change adaptation is mostly location-specific its effectiveness largely depends on the performance of local institutions and socioeconomic setting (Morton, 2007).So as to make policies and programs aimed at promoting fruitful adaptation options a better understanding of smallholder farmers' exposure to climate change and their efforts to adapt needs a close investigation.

Array of studies attested the potential detrimental outcomes of climate change on the Ethiopian agricultural sector (NMA, 2001; Kidane et al. 2006; Deressa, 2007). Yet, findings of the studies were mainly spotlighted on the impact of climate shocks on agriculture and suggested adaptation strategies. However, they failed to deal with the driving forces that determine household's choices of adaptation options. This indicates wide gap or limitation to better understand adaptation options and difficulties on the ground. Additionally, other studies have tried to assess impact of climate change and determinants of choosing different adaptation measures in mono-crop and diverse crop production scheme at the regional level in Africa (NMA, 2001; Schlenker et al. 2010; Seo & Mendelsohn, 2008). Due to the aggregate nature of these studies, however, it becomes cumbersome to address heterogeneity in agro-ecological aspects, socio-economic, institutional, and environmental issues. This has limited an effort to understand the role of adaptation measures, as the practice of different adaptation alternatives to climate change is context specific.

Further, few studies (Deressa et al., 2009; Tesso et al. 2012b; Balew et al. 2014; Debalke 2014) examined factors impacting the selection of adaptation measures. Nonetheless, they are far from reaching on similar consensus and revealed disparity in factors that influences farmers' decision to practice different adaptation methods in various areas of studies. This gap in obtaining clear scientific evidence has become stumbling block for the efforts to design appropriate development policies and interventions. Therefore, context specific assessment of the determinants of smallholders' decision in response to climate change is decisive to pinpoint main practices that could improve the use of appropriate adaptation strategies. Accordingly, the objectives of this study were to assess farmers' exposure to changing climate, to identify adaptation strategies used by dominantly sesame producers' smallholders and to investigate factors that affect smallholder farmers' decisions to employ a range of adaptation strategies in West Ethiopia.

3.2 Definition of Concepts

In the climate change literature, there exist various definitions of vulnerability. For the purpose of this study, we used one of the most widely applied definitions of vulnerability by the IPCC. Vulnerability is defined by IPCC as the extent to which a system is prone or unable to deal with

adverse effects of the changing climate including climate variability and extremes (IPCC, 2007a). This definition puts vulnerability as a situation of three interconnected variables which are exposure, sensitivity, and capability to acclimatize to climate change impacts (Gebrehiwot & Van Der Veen, 2014). Exposure is, defined by IPCC, as the nature and extent to which a system is exposed to major disparities of climate while sensitivity is the extent to which a system is influenced, either harmfully or usefully, by climatic shocks. Whereas, adaptive capability is the ability of a system to adjust, to moderate possible climate hazards, to benefit from opportunities, or to handle the resulting effects (IPCC, 2007a). In an effort to assess farmers' vulnerability studies indicated that the integration of the three indicating factors could be used (Nkem et al. 2007). It is also indicated that exposure to impacts are the first and main indicator in the vulnerability assessment.

Likewise, though literatures gives arrays of definition for the term adaptation, there is no single definition of universal application. In recent times, IPCC defines adaptation as 'adjustments in natural or human systems in reaction to real or anticipated climatic stimuli or their effects, which moderates damage or exploits favorable opportunities' (IPCC, 2014). This study applied IPCC's definition of adaptation to well understand farmers' responses to climate change and factors that determine their decision to use the adaptation options.

It is widely recognized that adaptation is one of the indispensable policy options in response the climate impacts (Smit et al. 1999; Fankhauser, 1996). In the IPCC fifth assessment report, adaptation is explained as "the potential to reduce adverse impact of climate change and to enhance beneficial impacts, but will incur costs and will not prevent all damages." There also exists recognition of the urgent desire to adapt to climate change and to assist countries in poor capacity to adapt, within the UNFCCC. Further, to address the adverse climate impacts the Kyoto Protocol (Article 10) urges all the concerning bodies to promote as well as facilitate adaptation and develops adaptation technologies (UNFCCC, 1998). Ethiopia, like many developing countries, recognizes adaptation as an important component of its climate change response strategy and is exploring adaptation options in several sectors.

3.3 Theoretical Framework: Sustainable Livelihood Framework (SLF)

This study aims at exploring farmers' exposure to climate change, decisions to use adaptation options and the determinants of their decisions. It is argued that adaptation is a complex, multidimensional, and multi scale process (Bryant et al. 2000). The SLF is known for promoting multi-dimensional understanding of the nature and dynamics of livelihood exposure and adaptation. In this study we used this perspective to draw lessons from livelihood vulnerability and responses of agricultural households in West Ethiopia. Sustainable livelihood literature is helpful in understanding the vulnerability of agricultural households to climate change, adaptation options and its determinants (Adger, 2006).

Studies showed that livelihoods are composed of a combination of assets that allow people to follow a combination of adaptation options to attain livelihood outcomes (Carney et al. 1999; Scoones, 1998). SLF is found to be useful in many ways. It provides insights on how people use a range of livelihood assets (natural, social, financial, human capitals) to devise adaptation options. Their ultimate aim is to achieve positive livelihood outcome-increased food security and reduced vulnerability (Moser et al. 2001). Second, the framework provides the basis for understanding how adaptation options can build adaptive capacity. This in turn, equips people to better cope with change by diversify their activities to increase resilience to unforeseen future change (Adger, 2003; Kelly and Adger, 2000). Finally, it broadens our knowledge on how people's adaptation options are shaped by institutions, organizations, policies, and legislation.

Literatures further indicate that limitations in the use of adaptation options arise from institutions, power, inequality and other social factors (Adger, 2006). Other studies also showed the existence of institutions impacts on household assets such as financial, social, physical and natural capital which finally determines adaptation options available for the people (Carney, 1998). The framework further explains on how the ability to pursue different adaptation options is dependent on how human, social and financial capital as well as physical assets and ownership of natural resources such as land.

3.4 Methodology

3.4.1 Methods of data analysis

In this study, data were summarized and presented using descriptive statistics such as frequency, percentage, graphs, figures, and tables. Also Chi-square tests and one-way ANOVA were used in order to compare the difference among groups for different socioeconomic, institutional, environmental and demographic variables. Rainfall Satisfaction index and temperature data were used to assess households exposure to climate change. Then, a multinomial logistic regression model was used to identify determinants of household's adoption of adaptation options. For this analysis, both Microsoft Excel and STATA version 14 were used.

Empirical Model Specification

Climate Adaptations Model: In this study, climate change adaptation strategies are modeled under the standard farm technology adoption framework. Representative risk-averse farm household face problem of choosing one or more climate change adaptation strategies that maximize the expected utility from final yield given production function, climatic condition, land, labor and other constraints. Optimization solution would result in an optimal adaptation measures undertaken by the representative farm household. Hence, the household's choice of climate change adaptation strategy is affected by a set of climatic as well as various socio-economic factors.

That is: $A_{ih} = f\ H_h, I_h, C_h, R_h$

Where, $A_{ih} = i^{th}$ adaptation strategy to climate change adopted by household h, H_h is a vector of household's characteristics including household size, household head's gender, age and educational level, I_h is a vector of access to both formal and informal institutions such as access to extension services, access to credit and local market for input and output, C_h is a vector of climatic variables and access to climate related information and R_h is a vector of human and capital assets such as labor and land ownership

Besides, representative utility maximizing household is supposed to choose one climate change adaptation strategy over another if and only if the expected utility or gain in farm yield derived from one adaptation strategy is greater than the expected utility in farm yield from the other. For

instance, a rational farm household chooses soil and water conservation over agronomic practices if and only if he expects more yield gain from adopting the former strategy than the latter.

Furthermore, in this study, it is assumed that household's decision to adopt or not to adopt a given adaptation measure is made at household level but not at specific plot level. Moreover, to be methodologically consistent, sample farmer households were asked questions about what adaptation measures and practices they have typically used in order to cope with the negative impact of climate changes. This enables us, in model specification, to take a single dominant adaptation strategy from multiple strategies that the farmers have been applying in response to climate change. A dummy variable is designed to measure whether farm households had adopted each adaptation in any of their farm so as to cope with observed climate change and variability. Hence, each adaptation strategy is measured at household level and modeled independently. Finally, multinomial logistic regression model is used to investigate the factors affecting households' decision regarding choice of adaptation strategies to climate change as identified in equation above.

Multinomial logit model specification

Literatures indicate two broad groups of adoption models based on the number of choices or options available to an economic agent (Greene, 2000). Binary models are very popular due to their desirable statistical properties of bounding probabilities between 0 and 1. Nevertheless, since a choice decision by farmers is inherently a multivariate decision using bivariate modeling excludes useful economic information contained in the interdependent and simultaneous choice decisions (Dorfman, 1996). Therefore, in order accommodated farmers decision of using multiple adaptation options in which the dependent variable is discrete, it is more appropriate to consider adaptation options as a multiple choice decision. Therefore, the appropriate econometric model would be either multinomial logit or multinomial probit regression model. Regarding estimation, both of them estimate the effect of explanatory variables on dependent variable involving multiple choices with unordered response categories (Greene, 2000). In this study, therefore, the determinants of farmers' adaptation decisions to climate change were analyzed using a multinomial logit (MNL)

This random utility model is commonly used as a framework in determining of farmers' choice for different adaptation options. Following Greene, 2000, suppose for the ith respondent faced with j choices, we specify the utility choice j as:

$$U_{ij} = X_{ij}\beta + \varepsilon_{ij}$$

If the respondent makes choice j in particular, then we assume that U_{ij} is the maximum among the j utilities. So the statistical model is derived by the probability that choice j is made, which is:

Prob (U_{ij} > U_{ik}) for all other k ≠ j

where U_{ij} is the utility to the ith respondent from adaptation strategy j, U_{ik} the utility to the ith respondent from adaptation strategy k.

If the household maximizes its utility defined over income realizations, then the household's choice is simply an optimal allocation of its asset endowment to choose adaptation strategy that maximizes its utility. Thus, the ith household's decision can, therefore, be modeled as maximizing the expected utility by choosing the jth adaptation strategy among J discrete adaptation strategies, i.e.,

$$\max_j = E(U_{ij}) = f_j(X_i) + \varepsilon_{ij}; \quad j=0...J$$

In general, for an outcome variable with J categories, let the jth adaptation strategy that the ith household chooses to maximize its utility could take the value 1 if the ith household chooses jth adaptation strategy and 0 otherwise. The probability that a household with characteristics X chooses adaptation strategy j, P^{ij} is modeled as:

$$P_{ij} = \frac{\exp(X_i^{'}\beta_j)}{\sum_{j=0}^{J}\exp(X^{'}\beta_j)}, \quad J = 0...3$$

With the requirement that $\sum_{j=0}^{J} P_{ij} = 1$ for any i, where P_{ij} = probability representing the ith respondent's chance of falling into category j; X = predictors of response probabilities, β_j = Covariate effects specific to jth response category with the first category as the reference.

To removes indeterminacy in the model an appropriate normalization is to assume that $\beta_1 = 0$ (this arise because probabilities sum to 1, so only J parameter vectors are needed to determine the J + 1 probabilities), so that $\exp(X_i \beta_1) = 1$, implying that generalized Eq. (4) above is equivalent to

$$\Pr(y_i = j / X_i) = P_{ij} = \frac{\exp(X_i \beta_j)}{1 + \sum_{j=1}^{J} \exp(X_i^{'} \beta_j)}, \quad \text{for} \quad j > 1$$

where y is a polytomous outcome variable with categories coded from 0… J.

Unbiased and consistent parameter estimates using MNL model assumes the Independence of Irrelevant Alternatives (IIA) that requires that the probability of using a certain adaptation method by a given household is independent from the probability of choosing another adaptation method. Hausman test was used to test the validity of the IIA assumption. On the other hand, the estimated coefficients of the model provide only the direction of effect of independent variables on dependent variables, but neither represents the actual magnitude of change nor probabilities (Tizale, 2007). Thus, we used the marginal effects measure of the expected change in the probability of a particular choice being made with respect to a unit change in an independent variable (Greene, 2000).

Indicators of climate change Vulnerability (Exposure)

Sensitivity, exposure, and adaptive capacity are the key factors that determine the vulnerability of households and communities to the impacts of climate change (Asfaw, & Admassie, 2004).It is also indicated that exposure to impacts of climate change are a good indicator in the vulnerability assessment. In this study, we adopted the exposure factor to assess smallholders' vulnerability to climate change. Though not compressive, it is believed to be good enough to

understand households' vulnerability to the climate impacts. Therefore, indicators of exposure factors are identified as essential elements of a basic vulnerability assessment.

Exposure is the nature and degree to which a system is exposed to climate variations (Asfaw, & Admassie (2004). Temperature and precipitation are critical parameters of climate which strongly influence people, biodiversity, and ecosystems. It is generally agreed that increasing temperature and decreasing precipitation are both damaging to the already hot and water scarce agriculture (FAO, 2007b). Exposure indicators selected for this study characterize the frequency of extreme events, a warning system for natural disasters, and variations in temperature and rainfall. Thus, reduced and variable precipitation and increased temperature in the study area show a high level of exposure to climate change.

3.4.2 Definition of variables and hypothesis

The potential explanatory variables, which were hypothesized to influence farmers' use of adaptation options in response to climate change and considered in the analysis, are often classified as personal, socioeconomic, institutional, and climate factors (Tafa et al., 2009; Bekele & Drake, 2003). As depicted in Figure 3 below the dependent variable in this study was the choice of an adaptation option. Table 7 presented the description, definition and unit of measurement for both explanatory and dependent variables. Additionally, the expected effects of explanatory variables along with source of literature were also given in the table below.

Table 7: Descriptions, definition, and values of variables used in empirical model

Variables	Definition	Value and unit of measurement	Effect	References[3]
Dependent variable				
Adaptation options	Adaptation options	It is a categorical variable which takes the value 0 for not using any adaptation option, 1 =adopting agronomic practices , 2 =using different livelihood diversification strategies , 3 = using soil and water conservation measure, and 4 = using small-scale irrigation		
Independent variable				
GENDERHH	Gender of the household head	It is dummy variable which takes the value 1 for male and 0, otherwise	"+", "-"	34, 36, 37, 38
AGEHH	Age of the household head	It is a continuous variable measured in years	"+", "-"	38, 39, 40, 41, 42
EDUCATION	Education status of the household head	It is continuous variable measured in years of schooling	"+"	32, 40, 43, 44
FAMILY SIZE	Number of family members	Refers to the number of members who are currently living within the family	"+", "-"	32, 38, 40
FARMSIZE	Hectare of land cultivated	It is continuous variable measured in hectare	"+", "-"	21, 39, 41, 42, 45, 46, 47, 48
LIVESTOCKTLU	Number of livestock owned by the household	It is continuous variable measured in TLU using conversion factors (Annex)	"+", "-"	39, 49, 50
SOCIAL CAPITAL	Number of social groups which a household head has a membership	It is dummy variable which takes value 1 if a household head is membership to greater than or equal to two social groups and 0 otherwise	"+"	32, 52, 53
ACCESS CREDIT	Access to credit services	It is a dummy variable, which takes the value 1 if the farm household access to credit and 0 otherwise	"+"	27, 32, 37, 42, 47
ACCESS TO EXTENSION SERVICES	Access to extension services	It is a dummy variable, which takes the value 1 if the farm household access to extension service, and 0 otherwise	"+"	32, 40, 45, 51
MARKET DISTANCE	Distance from the nearest market	It is a continuous variable measured in walking km from home to the nearest market	"-"	44, 55, 56, 57, 58
CROP FAILURE	Frequency of number of droughts over the past 20 years	It is continuous variable measured in number	"+"	61
TEMPRATURE PERCEPTION	Perception of households change in temprature over the past 20 years	It is a dummy variable, which takes the value 1 if the farm household percieve increase in temperature , and 0 otherwise	"+"	37
WARNING SYSTEM	Receive a warning about the flood/drought before it happened	It is a dummy variable that takes the value 1 if the household receives a warning about drought/floods before it occurs, and 0 otherwise	"+"	37, 55, 59, 60

[3]Where 34(Bayard et al., 2007); 36(Asfaw &Admassie2004); 37(Deressa et al., 2014);38(Dolisca et al.,2006); 39(Amsalu & De Graaff,2007); 40(Anley et al., 2007); 41(Arega et al.,2013); 32(Tizale, 2007); 42(Gebreyesus 2016); 43(Damena, 2012); 44(Maddison, 2006); 21(Deressa et al., 2009); 45(Asrat et al., 2004); 46(Kassa et al., 2013); 47(Gbetibouo, 2009); 48(Nyangena, 2008); 49(Tefera et al., 2004); 50(Eshete, 2007); 51(Kandlinkar&Risbey, 2000); 52(Coleman, 1998); 53(Dikito, 2001); 27(Deressa et al., 2009); 55(Nhemachena& Hassan, 2007); 56(Deressa et al., 2011); 57(Below et al., 2012); 58(Piya et al., 2013); 59(Thornton et al., 2006); 60(Aker, 2011); 61(Teshager et al., 2014)

3.5 Results and Discussion

3.5.1 Smallholders' Exposure climate change

In this study, two climatic variables namely precipitation and temperature were chosen to measure the vulnerability (exposure) of farm households to climatic shocks. Regarding rainfall situation five questions were included in the questionnaire following Abera et al. (2011). These questions include: Did the rainfall come on time? Was there enough rain on your fields at the beginning of the rainy seasons? Was there enough rain on your fields during the growing seasons? Did the rains stop on time on your fields? Did it rain during the harvest periods? A household was asked each of these questions. Then, value1 is assigned if a household experience timely, regular and sufficient rainfall during ploughing, planting, crop growing and harvesting periods and 0 otherwise. Finally, all responses were added up and divided by 5 to form subjective rainfall satisfaction index. The index value is specific to observed rainfall variability at each household's farm where lower values indicate higher vulnerability to rainfall shock and higher values indicate good farm-level rainfall conditions. Though subjective, this seems to be an appealing measure of observed rainfall condition because farmers have been doing farming for a generally long period and experienced real conditions of climate on their specific farms.

Then rainfall variability was proven using farmer subjective observation regarding timeliness and amount of rainfall in the area. Responses indicate high rainfall variability and unpredictability during the planting, crop growing, harvesting and post harvesting periods. Though majority of the respondents report that rainfall is coming on time, nearly 40% of the respondents experience insufficient rainfall during the crop planting period (see Table 8). This is unfavorable condition for agricultural production that can reduce crop yield by affecting early stage of growth. It also harms livestock production through affecting forages and grasses recovery, and growth. Additionally, more than 45% of the respondents has been observed too early and or too late stop of rain. Rain was not stopping on time for them it was quitting either too early or too late. This unfavorable rainfall conditions would aggravated food insecurity problem leaving significant proportion of sampled farm households vulnerable to risks of harvest loss pertaining to weather variability and climatic change.

Table 8: Observed rainfall amount and regularity in study villages

On your farms	Favorable Conditions (Percentage)		Unfavorable Conditions (Percentage)	
Rainfall coming on time	*Yes (on time)*	*(74.6)*	*No (too early + too late)*	*(25.4)*
Enough rain at the beginning of rainy seasons	*Yes (enough)*	*(62.7)*	*No (too little + too much)*	*(37.8)*
Enough rain during growing seasons	*Yes (enough)*	*(79.3)*	*No (too little + too much)*	*(21.7)*
Rains stopping on time	*Yes*	*(54.3)*	*Too early + too late*	*(46.7)*
Rain during harvest periods	*No*	*(62.8)*	*Yes*	*(38.2)*

Source: Computation based on survey data, 2017

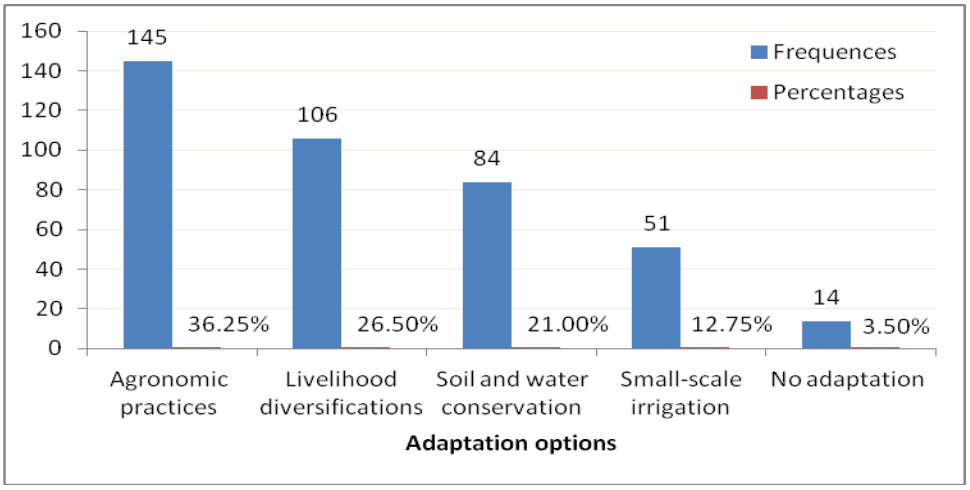
On the other hand, farmers were asked pattern of temperature change they have been noticed over the last two decades. Majority of them (83.75%) responded that temperature is increasing while 15.5% said it is decreasing. We further asked the farmers directly if they are facing climate change or not. 92.8% of them claimed that the climate change is the reality that they have been facing timely and again. And then, sample farmer households were asked questions about what measures and practices they have typically used in order to cope up with the negative impact of climate changes.

3.5.2 Adaptation strategies of smallholder farmers to climate change and variability

This section briefly summarizes farmers' adaptation strategies in response to climate change based on data from a comprehensive survey of agricultural households from two East Wellega sesame producing districts. The results show that adaptation strategies farmers used include using stone bund; check dam; terrace; small-scale irrigation; drought-tolerant and/or improved crop varieties; crop diversification; and off-farm activity. For the convenience of model analysis, the identified adaptation strategies are combined into five categories including the 'no adaptation' category. Use of drought-tolerant crop varieties, crop diversification, and improved crop varieties has merged together and categorized as an agronomic practice. Likewise, use of off-farm activities is merged together into livelihood diversification component. Also, stone bund, check dam, and terrace are grouped into soil and water conservation (SWC) measure.

Agronomic practice measures (36.25%) and livelihood diversifications (26.50%) were the two most widely used adaptation strategies in the study area (see Fig. 3). To minimize the risk from the total loss of crop production and to increase crop productivity, farmers' diversified crops grown on the same plot of farm, used drought-tolerant crop variety, and improved crop variety. Smallholder farmers were also engaged in diversifying their livelihood strategies using off-farm activities in addition to their farming practice. Farmers have also been using different livelihood strategies such as SWC and small-scale irrigation as a vitally important adaptation strategy in the face of the uncertainties due to climate variability (Fig 3).

Figure 3: Adaptation strategies used by smallholder farmers



It is also found that about 21% of the farmers started implementing SWC. They mostly apply stone bund, soil bund, check dam, and terrace. The use of these strategies was found to reduce soil erosion associated with short but heavy rains which are usually common in the study areas. Farmers also employed small-scale irrigation schemes (12.75%) over their farm as another important strategy in their efforts to adapt to the effects of climate change. On the other hand, the number of farmers who did not adjust their farming practices in response to climate variability was found to be small (3.50%). They cited shortage of sufficient financial resources, lack of climate related information and shortage of land as main reasons for not adopting.

3.5.3 Comparison of adopters and non-adopters of adaptation options

This section discusses the descriptive statistics of the dummy and continuous explanatory factors that were hypothesized to affect farmers' choices of various adaptation alternatives to overcome climate impacts (see table 9 and 10 below). These factors were categorized in to demographic, institutional, farm related and environmental characteristics.

Male household (89%) dominated our sampled population. It is also reported that 96.55% of the farmers' that practices agronomic options were male-headed households, while 0% of non-adopters were female-headed once. The Chi-square test revealed that the gender disparity between adopters and non-adopters were significant ($p < 0.002$). The average age of sampled households was 41.89 with no statistical significant difference among adopters and non-adopters of adaptation practices. The average size of sampled households was 6.69, which was over the national mean family size of 4.7 persons per household (Teshager et al., 2014). The mean of maximum school joined was 6.34. The mean of education level attained by implementers of irrigation practices (7.92) was much higher than that of non-adopters of any adaptation options (1.64). One-way ANOVA test showed that the average variation among implementer and non-implementer of any adaptation alternatives was statistically significant ($p < 0.000$).

The average farm size of the total sampled households was 3.65 ha with mean size of 1.5 and 4.54 ha for non-implementer and implementers SWC adaptation option, in that order. The mean livestock holding of the households was 4.82 in TLU. The average livestock holding for adopters and non-adopters of agronomic practices is 4.99 and 4.38, respectively. The statistical result shows that ownership of livestock was statistically significant (at less than 5%) between adopters and non-adopters.

The result showed that out of the total household heads only about 55% of them has access to extension services. The survey result indicated, about 32.25% of sample households get credit in any means, while 50.98% of them did not have that access. It is reported that 83.5% of households who practices small-scale irrigation has credit facilities, while; from among non-adopters, only 28.57% of households has access to credit. Statistically, this difference sounds at 5% level of significance. The result showed that on average 82.75% of farmers are member

social groups. The Chi-square test revealed that connection with any forms of cooperatives or social groups was considerably varied among adopters and non-adopter of any of adaptation alternatives ($p < 0.012$). Additionally, of total households only 39.42% has access to early warning information. Further, the one-way ANOVA test indicated a significant relationship among market distance and adaptation alternatives at less than 1% significance level.

Table 9: Differences of continuous explanatory variables between adopter and non-adopter households using one-way ANOVA

Continues variables	Adaptation options						
	Agronomic practices	Livelihood diversifications	Soil and water conservation	Small-scale irrigation	No adaptation	Average mean	Sig.
Mean Age of the HH	43.19	40.93	40.93	41.69	42.21	41.89	0.588
Mean Education of the HH	6.79	5.92	5.91	7.92	1.64	6.34	0.000
Mean of family size	6.85	6.61	6.41	6.47	8.14	6.69	0.203
Mean of farm size in ha	3.24	3.52	4.54	4.19	1.5	3.65	0.000
Mean of livestock in TLU	4.99	4.58	4.91	4.78	4.38	4.82	0.044
Mean of distance to market in km	1.51	2.02	7.59	2.13	2.09	3.02	0.000
Mean of number of crop failed experience	8.44	8.18	7.37	7.78	6.07	7.98	0.198

Table 10: Differences of dummy explanatory variables for adopter and non-adopter households

Dummy variables	Adaptation options						
	Agronomic practices	Livelihood diversifications	Soil and water conservation	Small-scale irrigation	No adaptation	Chi-square	Sig.
Gender of the HH (Female %)	3.45	16.04	15.48	17.65	0.00	16.95	0.002
Member of social groups (Yes %)	88.97	73.58	79.76	90.20	78.57	12.84	0.012
Access to credit (Yes %)	31.72	28.30	27.38	50.98	28.57	9.96	0.041
Access to extension services (Yes %)	54.48	51.89	54.76	58.82	71.43	2.26	0.688
Temperature perception (Increase %)	84.83	85.85	96.43	84.31	78.57	8.66	0.070
Access to climate change information/warning (Yes %)	91.03	81.13	91.67	82.35	85.71	8.04	0.090

3.5.4 Determinants of farmer' adoption of climate change adaptation measures

Prior to running the MNL model, multicollinearity was checked using VIF and CC. The results indicated that VIF for all variables is on average 1.03, which showed no serious multicollinearity problem among all the continuous explanatory variables. Likewise, the result from CC indicated no multicollinearity issue between dummy variables. Additionally, to check for the validity of the IIA assumptions we used Hausman test. The result of the test pointed the appropriateness of MNL model specification since it failed to reject the null hypothesis of independence of the climate change adaptation alternatives. Chi-square test showed highly significant ($p < 0.01$) likelihood ratio, which confirms that the model has a strong explanatory power. Furthermore, in estimation of MNL model, fifth category (no adaptation) was taken us as a base category. Table 11 below presented the estimated coefficients of the MNL model, while Table 12 reported the marginal effects from the MNL.

Household Characteristics

Agronomic practices were positively influenced by gender of the household at 1% significance level. Men are 29.55% more likely than female to adapt agronomics adaptation practices. Previous study also indicated the same as women's ability to access land and information to adapt agronomic practices were limited by cultural and social barriers (Asfaw & Admassie, 2004; Deressa, et al., 2014). On the contrary, female headed household adapt easily to changing climate through livelihood diversification. This is in line with the finding of Nhemachena and Hassan 2007.

The result shows significant impact of education on smallholders' effort to go for small-scale irrigation as their adaptation option. One additional school year would lead to 0.81% raise in the likelihood of opting for irrigation. This finding agrees with previous studies (Tizale, 2007; Anley et al., 2007; Damena, 2012). Further, opposite to our hypothesis, livelihood diversification practices was negatively and significantly ($p < 0.1$) affected by years of schooling. This can be explained by the fact that educated households may observe better return from on-farm doings than none-farm one that may have low return.

Resource Endowments

One hectare increase in farm size is found to have reduced the probability of implementing agronomic practices by 30.3%. This could be explained by the fact that farmers' with large farm size may worry less about climate hazards than the others with small land size. This agrees with the result of Deressa et al. 2011 and inconsistent with other studies (Gbetibouo, 2009; Bryan et al., 2009; Phillipo et al., 2015). On the other hand, larger farm size considerably raises the probability of implementing SWC alternatives at 1% level of significance. Previous literatures also support this result (Amsalu & De Graaff, 2007; Kassa et al., 2013; Gbetibouo, 2009).

It is found that the ownership of livestock has negatively related to livelihood diversification alternatives. It is indicated that the possibility of going for other means of living like petty trades and min-business decline by 5.1% when ownership of livestock raises by a unit. It is understood from this that smallholders with few possession of livestock were the one to go for non-farm diversification for living. This finding differs from the view that having many livestock may enable framers to generate more income which in turn would help them establish other source of living (Tazeze et al., 2012).

Institutional Factors

Being membership of various social groups (considered as social capital) was positively influenced the probability of adopting small-scale irrigation and agronomic practices at 10% and 5% level of significance, in that order. The probability of adopting agronomic practices and small-scale irrigation increases, respectively, by 14.71% and 6.47% as being part of a given social group increases by a unit. This is mainly due to the reason that access to different social groups may raises smallholders awareness on the adaptation alternatives. In line with this, Ortmun and King, 2007 and Mpogole, 2013 found that becoming a part of a given social network have tremendously raises the possibility of adopting improved and high yield variety. Other studies also confirmed this fact (Deressa et al., 2009; Mpogole, 2013).

The availability of credit has increased the likelihood of using small-scale irrigation by 13.93%. This is due to the reason that access to credit solves farmers' liquidity constrains and thus improves their ability to purchase irrigation facilities. Previous studies (Deressa, 2009; Tizale, 2007; Gbetibouo, 2009) confirm the same. The study result reveal that existence early warning

information has positive relation with agronomic and SWC practices. As indicated, getting access to climate warning raised the probability of agronomic practices (13%) and SWC alternatives (11.3%). Deressa et al. 2014 observed that access to climate change information has significantly helped farmers' to adopt diverse crop varieties. Similarly, Phillipo et al. 2015 found positive impact of access to information about flood and drought on adaptation practices.

Table 11: Parameter estimates of the multinomial logit climate change adaptation model

Adaptation Options	Agronomic Practices		Livelihood Diversification		Soil and Water Conservation		Small-Scale Irrigation	
Explanatory Variables	**Coef.**	**P-value**	**Coef.**	**P-value**	**Coef.**	**P-value**	**Coef.**	**P-value**
MALE HH	-12.121	0.985	-13.784	0.983	-13.842	0.983	-13.736	0.983
AGEHH	0.026	0.418	0.019	0.563	0.02	0.557	0.014	0.676
EDUCATION	0.461***	0.005	0.404**	0.014	0.440***	0.008	0.505**	0.003
FAMILY SIZE	-0.315***	0.008	-0.320***	0.007	-0.330**	0.010	-0.341***	0.008
FARM SIZE	0.884**	0.011	0.946***	0.007	1.086***	0.002	1.007***	0.004
LIVESTOCK TLU	0.792**	0.042	0.524	0.180	0.742*	0.067	0.654*	0.105
SOCIAL CAPITAL	-0.017	0.985	-0.320***	0.007	-1.176	0.226	0.157	0.879
CREDIT	0.271	0.731	0.412	0.603	0.213	0.799	1.454*	0.079
TRAINING	-1.601*	0.081	-1.656*	0.071	-1.205	0.205	-1.071	0.266
DISTACE MARKET	-0.207	0.200	-0.065	0.676	0.208	0.169	-0.022	0.893
CROP FAILURE	0.196*	0.088	0.178	0.122	0.188	0.114	0.126	0.290
TEMPRATURE PERCEPITION	0.661	0.443	0.695	0.423	2.381**	0.034	0.343	0.712
WARNING	2.045*	0.057	1.222	0.248	1.940*	0.087	0.877	0.430
_cons	8.741	0.989	12.122	0.985	7.638	0.990	9.911	0.988

Base category no adaptation
Number of obs. 400
LR x2 (52) 235.99
Prob> x2 0.0000
Log likelihood -452.984
Pseudo- R2 0.2067
***, **, * significant at 1, 5 and 10 probability level, respectively. HH is Household Head

Table 12: Marginal effects from the multinomial logit of climate change adaptation model

Adaptation Options	Agronomic Practices		Livelihood Diversification		Soil and Water Conservation		Small-Scale Irrigation	
Explanatory Variables	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value
MALE HH	0.2955***	0.000	-0.1526*	0.082	-0.0881	0.275	-0.0475	0.419
AGEHH	0.0018	0.403	-0.0006	0.775	-0.0004	0.826	-0.0008	0.589
EDUCATION	0.0085	0.222	-0.1053*	0.105	-0.0064	0.273	0.0081**	0.047
FAMILY SIZE	0.0052	0.619	0.0010	0.919	-0.0041	0.666	-0.0023	0.730
FARM SIZE	-0.3028**	0.030	-0.0025	0.818	0.0279***	0.001	0.0064	0.275
LIVESTOCK TLU	0.3388	0.141	-0.0507**	0.028	0.0256	0.203	-0.0056	0.690
SOCIAL CAPITAL	0.1471**	0.035	-0.0960	0.193	-0.1205	0.112	0.0647*	0.094
CREDIT	-0.0639	0.262	-0.0278	0.609	-0.0556	0.234	0.1393***	0.002
TRAINING	-0.0083	0.888	-0.0260	0.630	-0.0249	0.607	0.0556	0.121
DISTACE MARKET	-0.0370**	0.021	0.0096	0.459	0.0178*	0.102	0.0098	0.210
CROP FAILURE	0.0100*	0.109	0.0032	0.595	-0.0085	0.136	-0.005	0.220
TEMPRATURE PERCEPITION	-0.0834	0.330	-0.0487	0.548	0.2181***	0.000	-0.0677	0.293
WARNING	0.1302*	0.086	-0.1187	0.157	0.1131**	0.037	-0.1113	0.122

***, **, * significant at 1, 5 and 10 probability level, respectively. HH is Household Head

Market factors

Being far from market center deters farmers' possibility of agronomic practices significantly ($p < 0.05$). Numerous literatures argued that improved market access enhances smallholders' ability to adapt to climate risk (Deressa et al., 2011; Piya et al., 2013). Contrarily, SWC adaptation option was found to be positively related to market distances. This may be justified by the fact that smallholders' in the remote village have less opportunity cost to implement labor-intensive adaptation alternatives like SWC.

3.6 Conclusions and Policy Recommendations

The results show that the majority of the farmers have perceived changes in rainfall and experienced the effects of a changing climate (rising temperature) over periods. Smallholders' have been exerting efforts to adapt by practicing many adaptation strategies that can broadly categorized in to, agronomic practices, livelihood diversification, and small-scale irrigation and SWC measures. It is observed that using these adaptation alternatives are expected to enhance farmers ability to adapt to the changing climate caused risks.

Smallholders' ability to select appropriate adaptation alternatives was impacted by factors like household characters, farm size, social capital, access to credit and markets, access to climate information, and early warning. This urges for smallholders local adaptation strategies augmentation by a wide range of institutional, policy, and technology support. Any policy or programs that facilitate farmers' connection to many social groups, creates access to market and irrigation materials can promote and enhance adaptation efforts to overcome climate risks. Provision of microcredit facilities empowers farmers financially to opt for the capital intensive irrigation. Moreover, providing timely climate change information and effective early warning system is of paramount importance to bring desired impact on the adoption appropriate adaptation options.

Chapter Four

4. HOUSEHOLD FOOD SECURITY STATUS AND DETERMINANTS UNDER THE CHANGING CLIMATE: THE CASE OF SESAME PRODUCERS IN WESTERN ETHIOPIA

Abstract

Poverty and food insecurity remain major widespread challenges in rural Ethiopia. Climate variability and extremes further exacerbated these challenges by adversely affecting agriculture, the main source livelihood for the rural population. There was little attempt to study the state of food security of the cash crop growing farmers in Ethiopia. Assessing factors influencing rural household food security is very crucial as it provides information on household food security status that would help the policy makers for effective implementation of food security program. The purpose of this study was to examine the food security status and determinants of household food security of dominantly sesame producing farmers in west Ethiopia in the midst of climate change. Household survey among 400 randomly selected households was administered to collect the data. Descriptive statistics, household food insecurity access scale (HFIAS) and binary logit econometric model were used to analyze the data. The results of the HFIAS revealed that 65.8% of the households are food secure, while the remaining 34.2% are not. The binary logit regression results indicated that land holding, family size and livestock ownership are important factors influencing household food security. Moreover, it is found that adoption of soil conservation, small-scale irrigation and employing different agronomic practices has positively and significantly affected household's food security. Therefore, so as to improve the food security status of farmers, it is suggested that the investments on growing farmers' resource endowment, expansion of different agronomic practices and small-scale irrigation should be promoted.

Key words: Food security, climate change, adaptation strategies, determinants, Ethiopia.

4.1 Introduction

Food insecurity is a universal concern that looks to be more sever especially in sub-Saharan region of Africa. Food security exists when all people at all times have access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 1996b). This definition emphasizes the multidimensional nature of food security which includes include availability of food, economic and physical access to food, adequate food utilization and sustainably having access to adequate food (FAO, 2008). In long run lack of food leads to hunger and starvation (Gebre, 2014). Studies indicated that climate change potentially affected those foundation pillars at various stage and dislocated the connection among them, and dwindling the ability to deliver food security (Gregory et al. 2005).

Food insecurity issue is more pertaining particularly under imminent climate change which is commonly recognized to have major implications for agricultural production and food security (Thornton & Herrero, 2014; Demeke et al. 2011). The effect is persevere in the rural part of developing countries where the capacity to cope up the adverse effect of climate hazards is low (Demeke et al. 2011; Falco et al. 2011). In this region of the world, extreme droughts are causing difficulty in maintaining their food security and well-being by impede people's ability to grow food and rear livestock, (Songok et al. 2011). For instance, according to FAO 2015 report, level of undernourishment in SSA in 2014 and 2016 rose to about 220 million in comparison to the 180 million observed during 1990 and 1992.

As Ethiopia is not an exceptional the potential adverse effects of climate change on the agricultural sector, the main stay of the country's economy, are major concerns. The country is highly vulnerable due to poor adaptive capability of rural smallholders and high exposure to natural and anthropogenic hazards (WB, 2010; Conwayet al. 2011). Recently, the deadliest El-Nino episodes as never before have left the country in devastation. It plunged into rain-fed agricultural, challenging livings and making worse food insecurity especially for the poor and susceptible households (FAO, 2017). In 2016, this El-Nino plug left estimated 10.2 million

people to wait for food assistance and above one-third of the country's districts alarmed by food security and nutrition crisis (FAO, 2017).

In Ethiopia, efforts have been made to examine the extent and determinants of food insecurity (Bogale & Shimelis, 2009; Hadleya et al. 2011; Abebaw et al. 2011). Those studies dominantly focused on analyzing the demographic, institutional and socio-economic factors, they failed to rigorously investigate the climate factor that has been exacerbating food insecurity (Demeke et al. 2011) and none have shown how adaptation options impact food security status. In addition, recent study on food security indicated the need to be context specific in examining variables that are impacting food sector for appropriate policy interventions (Beyene, 2014). It is expected that close understanding of these factors would help food security policies and programs achieve their target by working on the specific factors. It may also helps in mainstreaming climate change issues during designing intervention programs that are more likely to contribute to food security enhancements.

Consequently, the aim of this paper was to examine the status and determinants of smallholders' food security in the study area. It was aimed to investigate array of demographic, socio-economic, institutional and climatic variables influencing farmers' food security of in Wes Ethiopia. This would be very helpful in updating and informing policy makers with local-specific hurdles in achieving food security and suggests the way out.

4.2 Definition of Concepts

The conventional definition of food security is "access by all people at all times to enough food for an active and healthy life" (WB, 1986). This indicates entitling not only to food availability but also food access through home production, purchase in the market or food transfer. The above definition lacks the utilization and stability dimensions of food security. Recognizing these dimensions, the 1996 World Food Summit define "food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life'' (FAO, 1996a). This definition conceptualized food security resting on four dimensions: availability, access, utilization, and stability.

It is highlighted by those definitions that food security is a multidimensional concept, the assessment of which requires the measurement of several indicators that can together capture the various dimensions of food security. As Webb et al. (2006) noted that these dimensions are inherently hierarchical; with food availability is necessary but not sufficient to ensure access, and then food access become necessary but not sufficient for effective utilization. In the meantime, the notion of stability cuts across the first two dimensions and can refer to variability and uncertainty in both availability and access. The existence of different dimensions' of food security calls methodological pluralism in measuring it. Literature on food security recognized a combination of measures and indicators is needed to fully reflect the complex reality of food insecurity in any given context (FIVIMS, 2002; Hoddinott, 1999).

On the other hand, food security would happen to a given individual in a community when he secures nourishment he needs both physically and economically (Reutlinger, 1987). In this view we can broadly categories household food insecurity in to: chronic and transitory food insecurity. Chronic food insecurity occurs when a household goes repeatedly high risk of inability to meet the food needs for his members. In contrast, transitory food insecurity is faced when a household suffers a temporary decline in the security of its entitlement and the danger of failure to meet food needs is of short duration (Reutlinger, 1987).

4.3 Theoretical Framework: Theory of Famine and Food Security

The aim of this study is to examine smallholders' food security status and determinants under the changing climate. Therefore, it is important to have food security in the theoretical perspective. This section examines four competing paradigms of famine causations: demographics (Neo-Malthusianism), environmental, economics (entitlement failures), and politics (complex emergencies).

Demographics (Neo-Malthusianism) Explanation: One of the easiest and commonest explanations of famine is population growth. This theory gets its root in Malthus's thesis- Essay on Principle of Population, 1798 (Malthus, 1960). It is argued that as land resources remain constant at best or deteriorate considerably, and as agricultural technology remain primitive.

Whilst, as a consequence of these and other adverse factors, agricultural production proceeds at a snail's pace, population growth, mainly as a result of very high birth rate, soars much faster (Mesfin, 1984). According to Malthus (1960), eventually, famine would act as a natural check on population growth, equilibrating the food demand with its supplies. However, Malthus's thesis has been criticized and rejected on many grounds. Primary, considering famine as 'natural check' on population growth control is repugnant. Again, Malthus failed to "anticipate the 'fertility transition' to small families as a living standard rose" and the "exponential increases in agricultural productivity" owing to technological advances which "pushes production above global demand" (Devereux, 2002).

Neo-Malthusians still pursuing Malthus's row of argument. Nonetheless, the neo-Malthusian approach is also criticized heavily. Like Malthus's crude argument, neo-Malthusians short sighted to predict the role of technology has in booming food production. Moreover, 'mass mortality famines' ('natural check') does not act as population control. Rather fast population growth has been witnessed in countries which were afflicted by various famine episodes in the past (Devereux, 2002).

Environmental 'Supply-side' Explanations: This approach focuses on environmental limitations on food output, mainly through the drought, floods and other climatic shocks. It observes mainly to the 'natural causes' which diminish the capacity of the natural resources to provide adequate food supply (Wisner et al. 2004). Of the major famine disasters in the past 30 years (e.g. in the Africa's Sahel zone, in Sudan and Ethiopia and in northeast Brazil), many have been explained principally in the popular media as being caused by drought. Recently, worldwide climate change has become an additional factor in explanations of the reduction or disruption of food output, especially in relation to drought (Downing, 1992). This view, however, come under critics based on natural events (like drought, flood and climate change) can act as triggers, rather than causing famines. This is because increased risks are caused by human actions, and relate to social vulnerability and to pre-existing 'normal' level of hazards. In other words, human action is responsible for both the generation of peoples' vulnerability and the increased level of hazard (Wisner et al. 2004).

The Political Economy explanation: This approach emphasizes the political economy and human rights, and the emerging complexities of contemporary famines. In this regard, a number of environmental and socio-economic attributes that are assumed to explain famine such as war and civil strife, ecological degradation, government mismanagement, unequal access to resources and unequal exchange, and socioeconomic and political dislocation have been pinpointed (Devereux, 1993). The argument here is that one or a combination of these can disrupt food production. Some writers hold the ideas that despite excess food somewhere in the world, famines occur in other parts of the globe due to denial of access to food resulting from lack of political commitment. Moreover, in spite of much discourse in achieving food security, donor nations and international organizations have channeled very limited resources for food security efforts in particular, and for development in general. The observed reality is the continuous fall in the flow of financial aid into Africa (Wisner et al. 2004; Mengisteab & Logan, 1995; Cheru, 1989).

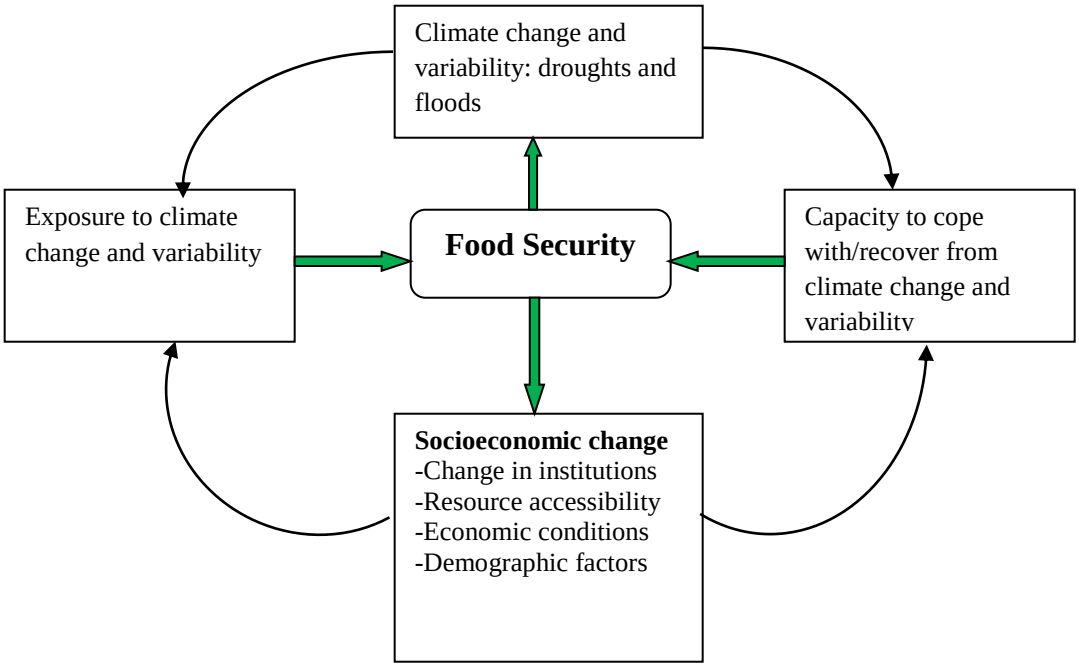
Some authors also considered famines as consequences of government action or inaction. They ascribe the responsibility for famine causation primarily to the political regime. Historical famines which were connected mainly to failure of the political regimes of the respective countries included the Soviet famines of 1921 and 1932/33; China's Great Leap Forward famine; the 1990-91 famine in Sudan (Devereux, 2000, 2002); the 1973-74 and 1984-85 Ethiopian famines (Fassil, 2005; Devereux, 2002; Mesfin, 1984). These examples indicate that even in earlier times, famines always had political dimensions.

Economic Explanation of Famine: In this economics perspective, there are two main economic explanations of famine based on different sets of causal explanations (Wisner et al. 2004). These are i) Food Availability Decline (FAD), and ii) Food Entitlement Decline (FED). The supply-side explanation is known as the FAD which refers to the fall in per capita food accessibility. But, the model is criticized for it overstating food supply and understating demand for food availability (Degefa, 2002). Sen (1981), presented the demand side explanations are known as FED model as an alternative method for the analysis of famine. The essential argument of FED is that a mere presence of sufficient food in aggregate terms does not necessarily entitle a person

to access to it. This means access to food plays a key role in securing command over food which is, in turn, determined by production, exchange or transfer.

Food availability and entitlement models are, however, not independent explanations, but in fact, complementary. In addition, they do not answer the problem at the household level. Food security at household level indicates the complementarities of the demographic, environmental political and economy explanations. Given all these prerequisite satisfied, still households must have the capability to acquire food for themselves. Thus the framework of this study connects the perspectives of the 'general explanations to famine', the two famine models and sustainable livelihood approach. The framework in Figure 4 depicts food security is not only determined by the situation and extent of climate change, but by the mixture of the individuals capability to cope with and/or recover from climate change, coupled with the degree of exposure to stress. The framework also shows coping capacity and degree of exposure are influenced by changes in social aspects such as institutions and resource accessibility. Change in food security aims at reducing vulnerability feedback to climate change through agricultural practices to increase agricultural productivity. Livelihoods addressed implicitly in that food security is an outcome of livelihoods.

Figure 4: Theoretical framework of Impact on Food Security



Source: Ericksen (2008)

4.4 Methodology

4.4.1 Methods of data analysis

The model specification and data analysis in this study has done in two steps. The first step was to specify appropriate model which enables us to know households' food security status, and the second stage was to specify the fitting model to examine factors that determines household food security in the study area. Excel and STATA version 14 were deployed to examine the data.

Household Food Insecurity Access Scale-HFIAS

To examine food security status, HFIAS was used to identify food insecure households (in terms of access), plus the frequency of occurrence of the event in the 4 weeks ahead of the survey (Jennifer et al. 2007). Accordingly, three food insecurity dimensions were captured: anxiety and uncertainty about the household food supply; insufficient quality (includes variety and preferences of the type of food); and, insufficient food intake and its physical consequences (Jennifer et al. 2007). HFIAS was then calculated by summing over the frequency-of-occurrence of food insecurity-related situations with higher values indicating severe food insecurity. Following the recommended cut-offs, households were then categorized into 4 levels of food insecurity: food secure, mild, moderately and severely food insecure (Jennifer et al. 2007).

HFIAS enables us to categories households based on responses to the nine severity items and coded "0" for "No" and "1" for "Yes" responses. It was scored as follows: "0" was attributed if the event described by the question never occurred, "1" if it occurred during the previous 30 days. With regard to the occurrence, "1" was attributed if the events rarely occur, "2" sometimes and "3" often. Then, to create household food security score, responses on the nine HFIAS questions were added with a minimum of "0" and a maximum score of "27." Accordingly, the higher the score, the more the household is vulnerable to food insecurity and vice versa. Consequently, HFIAS score of 0–1 is categorized as food secure, 2 and above were considered as food insecure. Households scored 2–7, 8–14 and 15–27 were grouped to be mildly, moderately and severely food insecure households, in that order.

Binary Logit Model

It is commonly argued that logit and probit models are usually used to establish the relationship between household characteristics and dichotomous response variable (food security and food insecurity). The advantages of these models over the linear probability model are that the probabilities are bound between zero and one. Moreover, they best fit the non-linear relationships between the response and the explanatory variables. The models specify a functional relationship between the probabilities of being food secure to various explanatory variables. In principle, one can substitute the probit model for logistic model, as their formulations are quite comparable; the main difference is that the logistic model has slightly flatter tails than the cumulative normal distribution, i.e., the probit curve approaches the axes more quickly than the logistic curve (Gujirati, 1995). Therefore, the choice between the two is one of (mathematical) convenience and availability of computer programs. Hence, the logistic model is selected for this study, although both logit and probit models may give a similar result.

The logit model is expressed as follows by Eq. (1) (Gujirati, 2000):

$$P_i = E(Y = 1/X_i) = \frac{1}{1+e^{-(\beta_o+\beta_1 X_i)}} \quad \ldots\ldots.1$$

For ease of exposition, Eq. (1) can be expressed as: $P_i = \frac{1}{1+e^{-Z_i}}$ …….2

Where, $Z_i = \beta_0 + \beta_1 X_i$. If P_i is the probability of being food secure, then the probability of being food insecure is given by $1-P_i$, which is expressed as follows by Eq. (3):

$$1-P_i = \frac{1}{1+e^{Z_i}} \quad \ldots\ldots..3$$

Therefore, this can be written as Eq. (4): $\frac{P_i}{1-P_i} = \frac{1+e^{Z_i}}{1+e^{-Z_i}} = e^{Z_i}$ ……4

Where, $P_i/(1-P_i)$ is simply the odds ratio in favor of food security; the ratio of the probability that the household will be food secure to the probability that it will be food insecure. Taking the natural log of Eq. (4) above, it is possible to arrive at a log of odds ratio, which is linear not only in X, but also in the parameters.

$L_i = Ln\left(\frac{P_i}{1-P_i}\right) = Z_i = \beta_0 + \beta_i X_i$ ……..5where, P_i is the probability of being food secured ranging from zero to one; Z_i is a function of n-explanatory variables (Xi) and is expressed as Eq. (6):

$Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_n X_n$ ……6 where, β_0 is the intercept or constant term; $\beta_1, \beta_2, ...\beta_n$ are the slope of the equation in the model (parameters to be estimated); L_i is log of odds ratio; X_i is a vector of relevant household characteristic.

If the disturbance term (U_i) is introduced, the logit model becomes:

$Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_n X_n + U_i$ ……..7finally, the parameters of the model are estimated using the maximum likelihood (ML) method (Gujirati, 2000).

4.4.2 Definition of variables and hypothesis

Following clear delineation of analytical procedures, identification of potential explanatory variables which can affect household food status is important. In this study, food security is dependent variable, which takes the value 1 if the household is food-secure and 0, otherwise. After close review of the literatures, the following explanatory variables were hypothesized to have an impact on our dependent variable.

It is likely that as age of the household increases the probability of being food secure raises mainly due to experience farmers would acquire in farming and weather forecasting. Previous study also showed the significant influence of age on household food status (Abebaw, 2003). Empirical analysis indicated that male headed household is more secure than their female counter parts, mainly due to females less access to improved technologies, credit, land and extension services (Belayneh, 2005; Christina et al. 2001). Moreover, in rain dependent economy along with limited agricultural inputs, having large family size will lead to higher food demand than the labor they contribute to production (Gemechu et al. 2016; Zemedu & Mesfin, 2014; Beyene & Muche, 2010). As a result, negative relationship between household size and food security it is hypothesized.

It is expected that educated household head have access to essential production information which could improve its food security statuses (Tirfe, & Hamda, 2011; Bogale & Shimelis, 2009). Likewise, studies revealed that households with larger farm size are more likely to be food secure than their counter parts. On the other hand, studies also indicated, the more the household possess livestock the more they become food secure (Tirfe, &Hamda, 2011; Bogale & Shimelis, 2009; Little et al. 2006). Moreover, it's observed that securing access to off-farm activities determines the success of household in managing food insecurity (Barrett, 2010; Gemechu et al. 2016; Tirfe, & Hamda, 2011). Contrarily, off-farm activities can take labor away from agriculture and may become threats to food security. Thus, involvement in off-farm activities can be positively and negatively related to food security.

Households that have an easy access to credit service could improve household's income and food consumption pattern (Beyene & Muche, 2010; Bogale & Shimelis, 2009). Similarly, findings showed access to climate information helped farmers to practice different adaptation options (Deressa et al. 2014). Timely early warning information systems empower households to overcome and adapt to climate risks (Hassan & Nhemachena, 2008). Further, local institutions (Tolosa, 2009) and social capital are vital in enhancing food security (Dzanja et al. 2015). As a proxy for social capital, membership to different social groups was used.

Studies indicated the importance of small-scale irrigation in boosting agricultural production especially in moisture-stressed area (Tirfe, & Hamda, 2011; Woldeab, 2003). In Ethiopia, soil erosion and degradation has considerably affects on efforts to achieve food security (Von et al. 2005). This indicates the importance of soil conservation techniques to mitigate land degradation and erosion to increase agricultural production. Moreover, improved seed varieties which may withstand drought and erratic rainfall distribution can boost overall production to enhance food security (Dorward et al. 2003; Lipton, 2005). Moreover, households near to market centers have advantage of getting access to additional income via off-farm employment and information on inputs (Gemechu et al. 2016; Dorward et al. 2003). Hence, we assumed negative relationship between distance to market center and household food status.

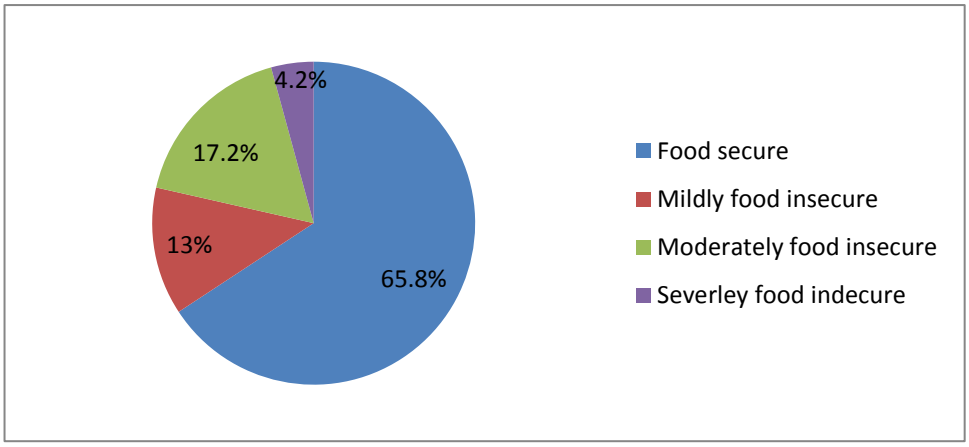
4.5 Results and Discussion

4.5.1 Status of Food Security

Fig. 5 presented the descriptive analysis of household food security status. HFIAS showed that from the total sample households, 65.8% households were found to be food secure. Among the participants, 137 (34.2%) labeled as food insecure based on their affirmative responses to the nine occurrence questions. According to the set cutoff points, 51 (12.8%) households classified as mildly food insecure, while moderately and severely food insecure were 69 (17.2%) and 17 (4.2%), respectively (Fig. 5).

The study finding revealed 125(31.2) of households worried about food inaccessibility and 160(40.0) households were not able to eat the kinds of food they preferred due to lack of resources. Additionally, about 164(41.0) households said that they did not consume a variety of food they prefer, 149(37.3) ate unwanted food, 115(28.7) ate small amount meal and 110(27.5) ate few meals per day. The share of households who experienced lack of food to eat was 75(18.8) and those who goes to bed without eating were 52(13.0), the study revealed (Table 13).

Figure 5: Household food security status in the study area, 2017



Source: Household survey, 2017

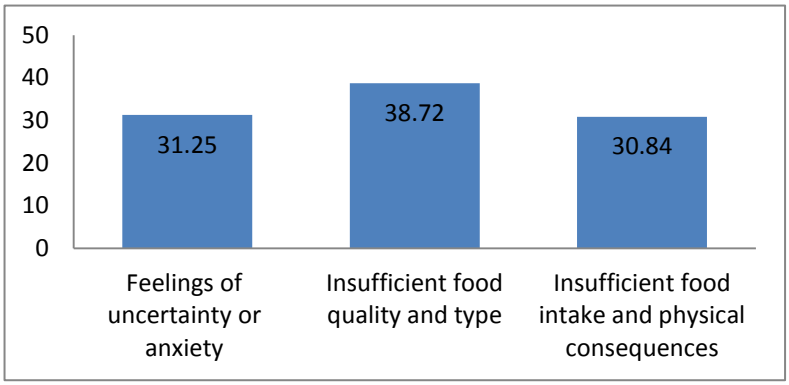
Table 13: Occurrence of HFIAS conditions in the study area, 2017

Indicators	No (%)	Yes (%)
Worry about not having enough food	275 (68.75)	125(31.25)
Unable to eat preferred food	240(60.0)	160(40.0)
Eat just a few kinds of food	236(59.0)	164(41.0)
Eat food really do not want	251(62.7)	149(37.3)
Eat smaller amounts in meal	285(71.3)	115(28.7)
Eat fewer meals in a day	290(72.5)	110(27.5)
No food of any kind in household	325(81.2)	75(18.8)
Go to sleep hungry at night	348(87.0)	52(13.0)
Go a whole day and night without food	375(93.8)	25(6.2)

Categories of household food insecurity in the study area

We can further group the nine occurrence items into three major domains: (I) feelings of uncertainty or anxiety about the household food supplies (captured under item 1), (II) perceptions that household food is of insufficient quality and food type preference (represented by items 2–4), and (III) insufficient food intake and its physical consequences (items 5–9 indicates).

Figure 6: HFIAS domain showing % distribution of households in study area, 2017



The result indicated anxiety and uncertainty domains was 125 (31.25%), the insufficient food quality domain was 155 (38.72%), while insufficient food intake and its physical costs domain was 123 (30.84%) in the study area (Fig. 6).

Table 14 presents the descriptive statistics for dummy and continuous variables to show the variation among both food secure and insecure households. The independent *t*-test indicated significant mean difference among the two regarding landholding, market distance and livestock

possession. The chi-square result showed that large number of food secured households implemented soil and water conservation, irrigation, drought-tolerant seeds and various livelihood alternatives. Further, many of food secure households were male households, members of many social groups, have access to extension, credit and early warning information in comparison to the food insecure once.

Table 14: Association between possible determinants and household food security

Variables	Food Insecure (n=137)	Food Secure (n=263)	Chi2 (P-value) or t-test (Std. Error)
Continuous Variables (mean)			
Age of the HH	41.058	41.038	0.016(1.251)
Education status of HH	4.088	4.646	-1.467(0.381)
Family size	6.869	6.441	1.438(0.297)
Landholding	3.118	4.078	-3.415***(0.281)
Distance to the market	1.919	2.409	-2.050**(0.238)
Livestock in TLU	3.796	4.411	-2.840***(0.217)
Number of drought occurrences	4.876	5.099	-1.047(0.213)
Discrete Variables (%)			
Gender of the HH (female)	5.11	3.8	0.378(0.539)
Off-farm income	29.2	27.38	0.148(0.700)
Advisory service	47.45	61.6	7.350***(0.007)
Access to credit	6.57	9.51	0.999(0.318)
Social capital	56.2	69.2	6.667*(0.010)
Early warning	68.61	75.29	2.034(0.154)
Soil conservation	6.57	11.41	2.396(0.122)
Small scale irrigation	78.1	82.89	1.355(0.244)
Drought-tolerant seeds	62.04	83.65	23.221***(0.000)

4.5.2 Determinants of Food Security

A binary logit model was employed to examine possible explanatory variables determining household's food status. Prior to running the model, multicollinearity was checked for continuous and dummy variables using VIF and CC, respectively. The test showed that there was no serious multicollinearity and association problem among the variables. Out of sixteen variables fitted into the model land ownership, family size, livestock ownership, soil and water conservation, small-scale irrigation and drought-tolerant seeds had positive relation with food

status. Except for credit, the effect of all the significant factors was in the anticipated direction. The binary logit model result of parameter estimates is presented under Table 15 below.

The result reveals that size of landholding has positively influenced household food security. When the area under cultivation is increased by 1 ha, the odds ratio in favor of food security increases by the factor 1.121. Different studies are in conformity with this finding (Beyene & Muche, 2010; Bogale & Shimelis, 2009; Haile et al. 2005). As expected, family size has negative and significant ($P < 0.05$) relation towards household food security. Numerically, as the family size increases by one person, the odds ratio in favor of food security reduces by the factor of 0.917. This could be explained by the fact that, given fixed farm size, increasing family size causes increasing food demand. Many empirical studies are in line with this result (Gemechu et al. 2016; Zemedu & Mesfin, 2014; Beyene & Muche, 2010).

The finding revealed that total livestock ownership has significant and positive implication for food security. As number of livestock rises by one TLU, the odds ratio in favor of food security increases by a factor of 1.151. This could be due to many contributions of livestock to the household's livelihood. This is in line with previous findings (Bogale & Shimelis, 2009; Tirfe, & Hamda, 2011). The model results in Table 15 below showed that use of drought-tolerant seeds has significantly contributed in food security improvements ($P < 0.01$). The odds ratio indicates that the probability of households to be food secure increases by 2.796, if a household has access to and uses drought-tolerant seed. This is convincible since in moisture-stressed area, due to climate change and variability, using drought-tolerant seed would reduce crop failure which in turn enhances crop production and food security.

Table 15: Parameter estimates of determinants of household food security

FoodSecurity	Odds ratio	Z-value	p-value
Female-headed HH	1.682	0.96	0.339
Age of the HH	1.011	0.96	0.336
Education	1.031	0.90	0.368
Farm size	1.121	1.91*	0.056
Credit	0.820	-0.42	0.677
Distance market	1.093	1.54	0.123
Family size	0.917	-2.04**	0.042
Social capital	1.473	1.50	0.134
Extension service	1.221	0.79	0.429

Early warning	1.599	1.60	0.110
Livestock TLU	1.151	1.84*	0.067
Number of drought occurrences	1.027	0.46	0.648
Drought tolerant seeds	2.796	3.70***	0.000
Of farm activity	0.786	-0.89	0.372
Soil conservation	4.124	2.72***	0.007
Irrigation	2.044	2.20**	0.028
_cons	0.041	-3.33***	0.001
Pseudo r-squared	0.119		
Log-likelihood function	-266.532		
LR $Chi^2(16)$	61. 098		
Prob > chi2	0.000		
Number of obs	400.000		

***, **, * significant at 1, 5 and 10 probability level, respectively HH: household head.

Moreover, the study result shows that adoption of conservation measures was found to have a significant influence on food security at less than 1% significance level. The find of other studies in another part of the country is also in line with this finding (Beyene & Muche, 2010; Holden, & Shiferaw, 2004). Small-scale irrigation as an adaptation response to climate change has also a positive and significant relationship with food security at 1% level. This is directly explained by the fact that irrigation allows farmer flexibility in length or number of growing seasons (Woldeab, 2003; Burke & Lobell, 2010) and it also helps to adopt new technologies (Hussain et al. 2004).

4.6 Conclusions and Policy Implications

This study examined the food security status and the determinants of household food security under changing climate among selected farm households. The household food insecurity assessment scale shows that 34.2% of the selected households were food insecure. By and large results disclose that adoption of adaptation options found to be significantly and positively influence household food security. In order to improve house hold food security status, it is, hence, essential to devise viable programs on soil conservation, irrigation and agronomic practices in harmony with smallholders existing resource endowments.

Family size is found to have negative relation with household food security. Therefore, it would be of great importance to have a policy apparatus that promote rural job creation to easy dependency level. The study result further indicated the significant positive impact of livestock ownership and size of landholding on household food security. These calls for an effort in promoting and supporting smallholders to improve the development of livestock assets and optimal land allocation decisions in order capacitate them to adapt to the emerging climate change and variability.

Chapter Five

5. IMPACTS OF ADAPTATION TO CLIMATE CHANGE ON FOOD SECURITYAND LEVEL OF SESAME PRODUCTION

Abstract

Farmers practices a number of adaptation alternatives in response to the changing climate. This study examined the role of those adaptation measures in improving farmers' food security and enhancing level of sesame production in rural area of western Ethiopia. In addition to meteorological data, cross-sectional data was collected interviewing 400 farm households. The analysis indicates that households are adapting using various strategies to the looming climate change in the area. The study also indicated that, though sesame production was negatively impacted by the climate hazards, smallholders have continued its production at minimum level due mainly to its high value crop character. Two-Stage Least Square (2SLS) estimation results revealed that both precipitation and temperature unpredictability has negatively impacted household's food status. Additionally, result indicated the importance of climate adaptation measures namely agronomic practices, irrigation and soil and water conservation in dropping climatic effects and enhancing household food security. The result also implicitly indicated that farmers continued to adapt sesame production under risk climate and it is contributing to farmers' food security. Further, the result revealed that climate change adaptation strategies have positively impacted the level of sesame production. Consequently, policy that augments households' climate awareness and promotes adaptation decision and strategies would contribute much in minimizing climatic hazards and in so doing advances households food security status and production of high value export potential crop-sesame.

Keywords: Climate change, Adaptation, Impact, Food Security, Sesame, Two-Stage Least Square, Multinomial Logit, Truncated Model, Western Ethiopia

5.1 Introduction

Climate change has become increasingly recognized as a global phenomenon with possibility of extensive implications (Stern, 2006; IPCC, 2007b; IPCC, 2014; IPCC, 2018). Agriculture is expected to be negatively hit in many regions through the greater occurrence and extent of excessive weather occasions like droughts and floods (IPCC 2011; Challinor et.al. 2009). In the developing regions, the climate change impact on poor people living in agricultural communities is anticipated to be worse (Maskrey et al., 2007).

Arrays of scholars studied the impact of climate change on food security in SSA using either agronomic model or Ricardian analysis (Deressa and Hassan 2009; Conway 2011; Beddington et al. 2012; Thornton et al. 2012; Thornton and Herrero 2014). From recent studies on vulnerability and poverty in Africa, Ethiopia has become one of the main susceptible countries to climate change and with poor adaptive capacity (Orindi et al., 2006; Stige et al., 2006). As it has been recorded, Ethiopia's economic growth has been cut by one third due to the extreme climate incidents like drought and floods (WB, 2006). Climate caused harvest failure is the prime reason for risk-related adversity of Ethiopian rural households, with adverse effects on farm household consumption and welfare (Dercon 2004, 2005).

As a strategy to protect and improve the livings of the poor and to guarantee food security, the top concern for agricultural development is to reduce the vulnerability of agricultural systems to climate change (Bradshaw et al., 2004; Wang et al., 2009). A bulky of literature has recognized adaptation as one of the policy alternatives in reply to climate change blow (Smit et al. 1999; Smith and Lenhart 1996; UNFCCC 1992). It is defined as "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (FAO 2011; IPCC 2011).

Studies reveal that without adaptation strategies, climate change is generally damaging to agriculture, but can partially be offset by different adaptation methods at the farm level (Reilly et al. 1999; Smit and Skinner, 2002). To harness climate posed difficulties, several potential adaptation alternatives have been recommended for developing countries. For instance, SWC practices have been suggested in reaction to soil erosion crisis caused by climate (McCarthy et

al. 2011; Amsalu and De Graaff 2007). Similarly, the application of different agronomic practices like drought resistant crop varieties, crop diversification, and improved crop varieties were taken as the potential adaptation practices (Lobell et al. 2008; Ellis and Freeman, 2004). Moreover, studies showed the importance of adoption small-scale irrigation schemes to overcome the impact of the unpredictable and irregular trends of rainfall and frequent drought (Amare and Simane 2017b). Livelihood diversification such as off-farm activities is also another adaptation option widely practiced by smallholder farmers aimed at enhancing their incomes and spread the risk (Amare and Simane 2017b; Morton 2007). The degree to which the agricultural sector is affected by climate change depends on the adaptive capability of the farming communities (Gbetibouo, 2009).

Empirical literatures shows that, in Ethiopia, efforts have been made to assess impacts of climate change impacts on agriculture and identified the existing adaptation alternatives (Asfaw et al. 2015; di Falco et. al 2011; McCarthy et al.,2011; Deressa 2007; Kidane et al. 2006). These studies are of great importance in revealing the extent of the climate impact and recommending different adaptation options. This day, however, despite the increasing promotion and use of different adaptation strategies, there exist few empirical studies that tried to examine its impacts on household food security. For instance, Ali and Erenstein 2017 showed the positive relation between adaptation practices and food security. Likewise, Gebrehiwot and Anne Van Der (2015) proved the same. Moreover, it is found that the adoption of climate-smart agricultural practice has affirmative and important impacts on the objective measure of food security Asfaw et al. (2015).

As far as we know, Ali & Erenstein (2017); Asfaw et al. (2015); Gebrehiwot & Van Der Veen (2015) and di Falco et al. (2011) are the only studies that attempt to evaluate the impact of adaptation on food security. While these impact studies provide valuable information they more focused on how the changing climate is likely to affect yields and crop production. Moreover, the results from these studies are highly fragmented, and inadequate to address local context and different dimensions of household food security. For instance, study by di Falco et al. (2011) by emphasizing only on agricultural productivity gives a partial assessment of food security-adaptation relationship. However, none of these studies have evaluated the relative impact of

different adaptation alternatives in reply to climate change on food security. Similarly, we have found no study that deals with the impact of different adaptation strategies specifically on sesame crop production. The current study aims to investigate how farmer's decision to adopt different adaptation measures in response climate change affects household food security and level of sesame production in the study area. This seems particularly relevant because most of the debate on the effect of climate change in agriculture has been focusing on the impact of climate change rather than on the role of adaptation.

To fill this gap in literatures, our current study intended to give a comprehensive examination on the impact of adaptation measures to climate change in Western Ethiopia. We used a cross sectional sampled data from 400 household in the study area were used. The specific purpose of this paper was then to examine effects of adoption of the four dominant adaptation options namely agronomic practices, livelihood diversification, soil and water conservation, and small-scale irrigation as on household food security status. Additionally we have also analyzed how these adaptation measures have impacted the level of sesame production. This has been measured by household food insecurity assess scale using two-stage least square model and truncated regression model. Achieving this objective gives empirical evidence on the role of adaptation measures to improve household food security and level of sesame production. Additionally, the finding of this paper is expected to inform policy makers design context specific and appropriate adaptation interventions in the study area.

5.2 Methodology

5.2.1 Data and methods of data collection

FGDs and household survey were used to collect household level data. There were six focus-group discussions held in two district of which three were in Gida Ayana and three in Sasiga. The focus groups discussion includes six to eight individuals of different combination like elder, women, development agent, local leader and farmers. Additionally, in this survey, two climatic factors, rainfall and temperature, were used to evaluate the susceptibility of households to climatic shocks. Time series data of rainfall was obtained from Ethiopian NMA. However, there was lack of household level disparity in precipitation data. To partly fill this gap, qualitative data on farmers' climate experience was collected. Moreover, farmers were asked pattern of

temperature change they have been noticing over the last two decades. This enables us to understand how the smallholder farmers have perceived the change in temperature.

5.2.2 Methods of data analysis

Empirical Models Specification

Household Food Security Model: is an empirical model that was estimated to examine impacts of socioeconomic variables, climate and adaptation options on household food security. For this purpose, food security index constructed based on HFIAS was used as a dependent variable.

So as to examine the role of climate change adaptation measure in achieving household food security, four dominant strategies were selected. We created dummy variables taking value "1" if a household employs a given method or adaptation strategy and "0" otherwise. These adaptation dummies were added to the food security model separately per se and not as a package. This was because household's decisions with respect to various adaptation options were assumed to be independent, as discussed in the previous chapter (Ch-3). In order to identify most effective strategy a separate inclusion of each adaptation in food security model was imperative.

On the other hand, household's decision to adopt climate adaptation alternatives can be affected by unobserved individual heterogeneity. This could be the unobservable farmers' skills or ability to learn and adopt new technologies. Therefore, unnoticed heterogeneity would result in the endogeneity problem. A situation when some of the explanatory variables may be correlated with the error term of regression model. Hence, before any analysis the endogeneity of adaptation variables was checked for using tools like Durbin-Wu-Hausman test. The test showed that adaptation decisions were endogenous. This causes difficulty in obtaining unbiased and inconsistent estimation of food security model parameters. In such situation, it is also impossible to find true effects of adaptation strategies. As a result, to obtain unbiased and consistent estimates we need to control for endogeneity problem. Accordingly, using 2SLS estimation framework is essential in obtaining robust estimates since it controls for endogeneity bias.

Consequently, 2SLS estimation framework was employed to estimate food security model. Following Kelejian (1971), Angrist (2001), and Angrist and Krueger (2001), predicted values of

endogenous adaptation dummy variables were used as an instrument. This approach of using predicted values as an instrument was employed in previous studies by Pender et al. (2004), Abera et al. (2011) and Di Falco et al. (2011c).

The standard requirement for the instrumental variables' appropriateness was that instruments should not be associated with the error term in structural equation but instead be correlated with the endogenous variables. In this case, excluded instrument must not be correlated with farmers' unobservable individual skills. Instead, they should be correlated with farmers' decision concerning climate change adaptations. To test instrument relevance, F-test of overall significance of excluded instruments was used. Finally, a multivariate econometric model was specified as follows:

HFIASi= f (H, L, S, LO, I, SRI, T, Di)…….2

where; HFIASi = Household's food insecurity access index calculated using nine indicators to access the status household food security. H = Vector of household characteristics such as age, sex and education of household head, and household size, L = Total amount of labor hours spent per hectare of cultivated land. S = Size of the cultivated land held by household measured in hectares, LO = Household's livestock ownership in TLU, I = Total amount of non-farm income earned by the household, SRI = Subjective observed rainfall satisfaction index used as a measure of rainfall variability. T = Household specific temperature variable proxied by altitude. Di = dummy variables for each typical adaptation strategies used by each farm household.

Before executing regression analyses, multicollinearity problem among the explanatory variables was checked using VIF for continuous variables and CC for discrete variables. Results of VIF which was less than 10 and CC less than 0.75 imply no serious multicollinearity problem among the variables. In addition, the problem of heteroskedasticity was checked using standard Breusch-Pagan/Cook- Weisberg test for heteroskedasticity. Resulting P-value of 0.98 indicates that the null hypothesis of homoscedasticity among the explanatory variables included in both models cannot be rejected.

Truncated Model

This was the second empirical model specified to examine impact of climate adaptation strategies, socioeconomic variables and institutional factors on the level of sesame production. Truncated regression would enable us to examined factors affecting the level of sesame production, conditional on participation decision. Thus, it involves the truncated regression that can be specified as: $L = L^{*}$ if $L^{*} > 0$ and $Y = 1$ $L = 0$ otherwise

From this, we can specify the reduced form of the truncation model as: $L = \beta_0 + \beta_i Z_i + \upsilon_i$

where L is the size of land allocated to sesame production in hectare, L* is the latent variable which indicates the land size is greater than zero, β_i is the vector of parameters to be estimated, Z_i is the vector of exogenous explanatory variables and υ_i is the error term. The empirical model used in this study assumes that the total hectares of land allocated for sesame production was a linear function of continuous and dummy explanatory variables and was specified as follows:

$$L = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + ... + \beta_{14} X_{14i} + \upsilon_i$$

where L was the size of land allocated to sesame production in hectare in 2017 production year, βi's – are the coefficients to be estimated and υ_i is the error term. The list of X_{1i} to X_{14i} includes adaptation strategies, household characteristics, socio-economical, institutional and climatic factors.

5.2.3 Selection of Instruments

We obtained and used four instrumental variables in getting the predicted values of the endogenous adaptation strategy variables. These instruments used in obtaining the predicted values of the agronomic practices, livelihood diversifications, soil and water conservations and small-scale irrigations were, respectively, access to agricultural extension services, market access, access to climate information and cooperative memberships. In addition to statistical test, the selection of those instruments was guided by previous empirical literature (Anley et al. 2007;

Tizale, 2007; Asrat et al. 2004; Bekele & Drake, 2003; Kandlinkar&Risbey, 2000; Below et al., 2012; Deressa et al. 2011; Hassan & Nhemachena, 2008; Maddison, 2006)

Access to agricultural extension services*:* Extension education has become very essential in helping farmers use agronomic practices, SWC and irrigation (Asrat et al. 2004; Anley et al. 2007; Tizale, 2007). Therefore, extension service is hypothesized to affect the decision to use different adaptation alternatives. ***Market access:*** Input markets let households to obtain the inputs they look for (Hassan & Nhemachena, 2008) and households located farther away from markets are less likely to adopt adaptation practices (Below et al., 2012; Deressa et al. 2011; Hassan & Nhemachena, 2008). It also encourages them to diversify their livelihoods by taking part in petty trade, hard craft work and daily labor employments. This indicates that the households located farther away from the input and output market is less probable to practice livelihood diversification options.

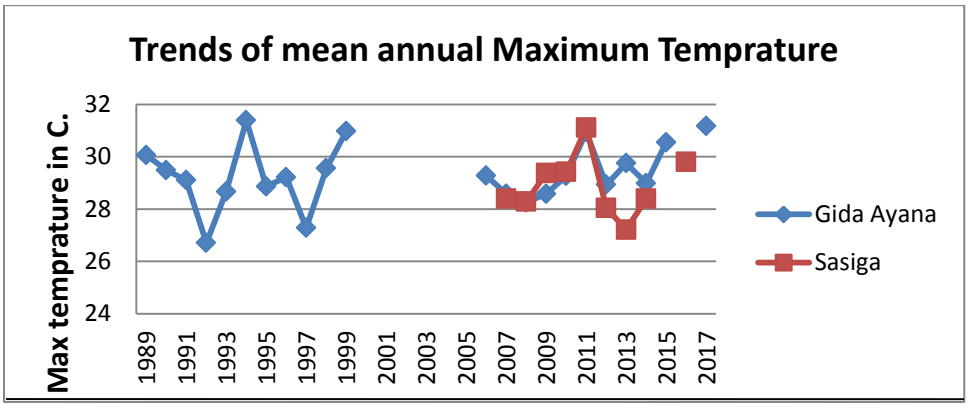
Access to weather information: Studies by Deressa et al. (2014) and Nhemachena & Hassan (2007) showed the positive impacts of better access to weather information on the decision to adopt SWC measures, irrigation, drought tolerant crop varieties, and living diversification in the response to climate change problem. So we expect positive impact of timely access to climate information on efforts to adapt different adaptation alternatives like SWC. ***Membership in a social group:*** cooperative and formation of different social networks are very vital way in achieving social capital and ensuring dissemination and adoption of innovative technology (Mpogole, 2013; Tafa et al. 2009; Dikito, 2001) Thus, it is believed that membership in social groups positively affects adoption small-scale irrigation as a response to climate impact.

5.3 Results and Discussion

5.3.1 Climate Change and Farmers Adaptation in the Study Area

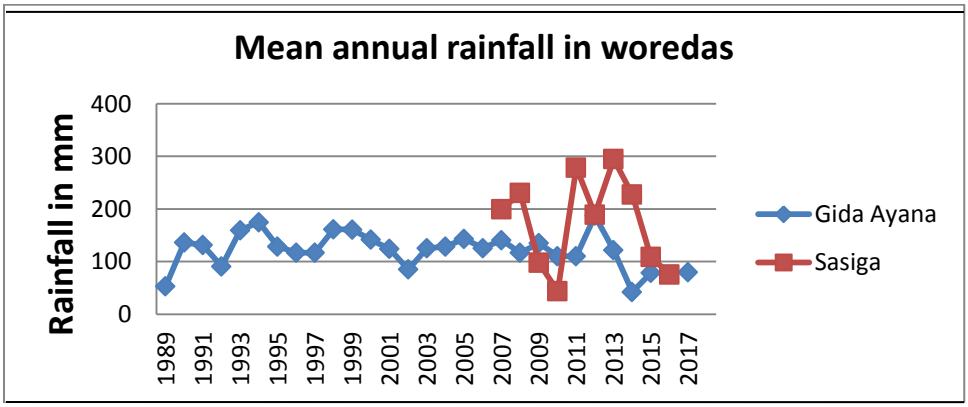
Fig. 7 present the 30 years trend in the annual maximum temperature data from the year 1989 to 2017 for the three metrology stations that exists in the study area namely Anger station for the Gida Ayana district and Sasiga and Ehud Gebiya stations for the Sasiga district. Similarly, Fig. 8 shows the trend in the yearly rainfall variation the area. Mean annual temperature was highly fluctuating and shows rising trend after 2013 in both districts.

Figure 7: Annual maximum Temperature in sampled districts, 1989-2017



The rainfall trend indicates high variability and general decline in the study district. In Gida Ayana district, the result revealed a sharp decline in rainfall values from 1998 to 2001 and from 2012to 2014. Additionally, sharp decline in rainfall was observed from 2013 to 2016 in Sasiga district. Such variability was perceived to be the main cause of crop production and productivity decline in the study area.

Figure 8 : Annual Rainfall in sampled districts, 1989-2017



Similarly, rainfall variability was proved using farmer subjective observation regarding timeliness and amount of precipitation in the area. Responses indicate high rainfall variability and unpredictability during the planting, crop growing, harvesting and post harvesting periods. Though majority of the respondents report that rainfall is coming on time, nearly forty percent of the respondents experience insufficient rainfall during the crop planting period (see Table 16 below). This is unfavorable condition for agricultural production that can reduce crop yield by affecting early stage of growth including seed germination. It also harms livestock production

through affecting forages and grasses recovery, and growth immediately after the end of the dry season.

Table 16: Observed rainfall amount and regularity in study villages

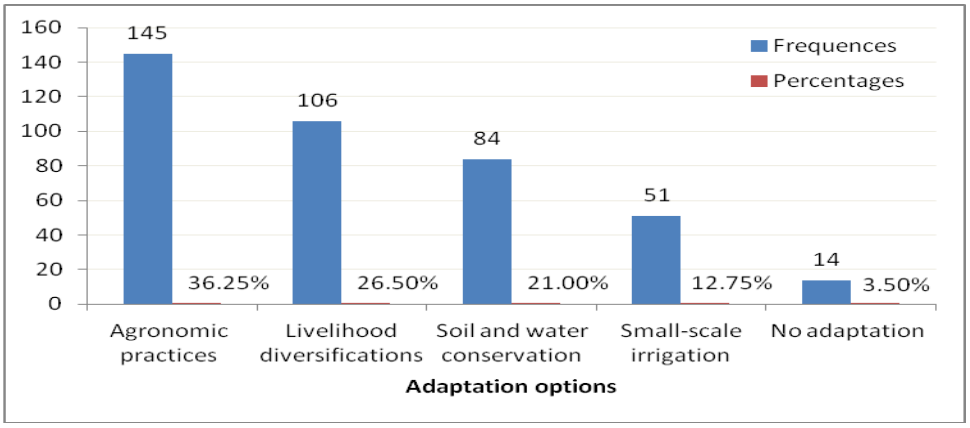
On your farms	Favorable Conditions (Percentage)		Unfavorable Conditions (Percentage)	
Rainfall coming on time	*Yes (on time)*	*(74.6)*	*No (too early + too late)*	*(25.4)*
Enough rain at the beginning of rainy seasons	*Yes (enough)*	*(62.7)*	*No (too little + too much)*	*(37.8)*
Enough rain during growing seasons	*Yes (enough)*	*(79.3)*	*No (too little + too much)*	*(21.7)*
Rains stopping on time	*Yes*	*(54.3)*	*Too early + too late*	*(46.7)*
Rain during harvest periods	*No*	*(62.8)*	*Yes*	*(38.2)*

Source: Computation based on survey data, 2017

On the other hand, farmers were asked pattern of temperature change they have been noticing over the last two decades. Majority of them (83.75%) responded that temperature is increasing while 15.5% said it is decreasing. We further asked the farmers directly if they were facing climate change and variability or not. 92.8% of them claimed that the climate change and variability is the reality that they have been facing timely and again.

And then, sample farmer households were asked questions about what measures and practices they have typically used so as to adapt to climate difficulties. The results showed that agronomic practice measures (36.25%) and livelihood diversifications (26.50%) are the two mainly practiced adaptation alternatives in the districts (see Fig. 9). Agronomic practice involves diversifying crops grown on the same plot of farm, using drought-tolerant and improved crop variety. It is also indicated that households were taking part in or diversifying their livelihood so as to earn more income and reduce the climate induced risks (Fig 9).

Figure 9: Adaptation strategies used by smallholder farmers



It is also found that because of the unpredictable and variable trend of precipitation and recurring drought, about 21% of the farmers started implementing SWC. Farmers also employed small-scale irrigation schemes (12.75%) over their farm as another important strategy to combat the hazards. Further, the percentage of households who has not been practicing any adaptation measures as the response to climate change was found to be small (3.50%). They pointed at lack of adequate finance, lack of climate related information and shortage of land as main reasons for not adopting.

5.3.2 Impact of Climate Change Adaptation on Food Security

It is expected that households' food security has been influenced by multidimensional factors, thus, in this study; it's modeled as a function of multiple socioeconomic and climatic factors. Prior to model parameters estimation we have tested for endogeneity of climate adaptation variables using Durbin-Wu-Hausman test. Based on the test results failed to reject the null hypothesis of endogeneity adaptation decisions implying endogenous nature of adaptation variables.

Table 177: Results of Endogeneity and Weak Instrument-Just identification Tests

Test	Score	P-Value
Test of Endogenity (H0: variables are exogenous)		
Durbin Chi2(4)	10.1716	0.0039
Wu-Hausman F(4, 387)	10.1213	0.0044
Weak Instrument test of just Identified Model		
Robust F(4, 388)	72.3336	0.0000

Moreover, weak instrument test of just-identified model was tested using robust F-test. The test indicated that there was no weak instruments since the F-value of 72.334 was by far greater than 10 (see Table 17). Hence, the instrumental variables were highly correlated with their endogenous variable counter parts appealing to the validity of the instruments. The test results confirmed that we can meaningfully interpret the coefficients obtained from 2SLS regression analysis.

The coefficient of altitude, which can be used as a proxy for temperature, is positive under agronomic practices, livelihood diversifications and irrigation adaptation options. From the reality of inverse relationship between altitude and temperature we can infer that temperature is negatively related to household food status. Our finding showed, one unit raise in temperature can cause to 3.34, 8.25 and 1.23 percentage decline of household's food security situation under give adaptation alternatives, respectively. Similarly, previous studies also confirmed the inverse relationship between temperature and food security (Muamba and Kraybill, 2010; Deressa and Hassan, 2009; Di Falco *et al.*, 2011c).

Table 188: 2SLS Estimation Results of Climate Change Adaptation impact on Food Security

	Agronomic Practices	**Livelihood Diversifications**	**Soil and Water Conservations**	**Small-Scale Irrigation**
	Dependent Variable: Food Security-HFIAS			
Explanatory Variables				
Adaptation	0.3182**(0.1642)	-0.1324(0.1700)	0.2672**(0.1375)	0.3121*(0.1766)
Rainfall Variability	0.3911***(0.0624)	0.0765*(0.0449)	0.2529***(0.0626)	0.2672***(0.0712)
Altitude	0.0334***(0.0131)	0.0825***(0.0111)	0.0086(0.0062)	0.0101(0.0063)
Education	0.0035(0.0048)	0.0167***(0.0057)	0.0209***(0.0065)	0.0211***(0.0066)
Farm size	0.0126***(0.0067)	0.0076(0.0083)	0.0125*(0.0076)	0.0117*(0.0073)
Family size	0.0047(0.0067)	0.0029(0.0083)	-0.0272***(0.0088)	-0.0269***(0.009)
Livestock TLU	0.0099(0.0065)	0.0169**(0.0082)	0.0198**(0.0093)	0.0191**(0.0084)
Age of the HHH	-0.0028*(0.0015)	-0.0005(0.0020)	0.0017(0.0021)	0.0018(0.0022)
Sex of the HHH	-0.0041(0.0507)	-0.0407(0.486)	-0.0525(0.690)	-0.0350(0.0762)
Non-farm Income	0.0001(0.0002)	0.0001(0.0003)	-0.0001(0.0003)	-0.0001(0.0003)
Daily labor hours	-0.0007(0.0063)	0.0040(0.0079)	0.0036(0.0085)	0.0034(0.0085)
Constant	-0.3275(0.2121)	-0.9525(0.2587)	0.2788(0.2118)	0.2198(0.2365)
Number of Observations	400			
Wald Chi2(11)	510.21	194.59	71.93	71.45
Prob.>Chi2	0.0000	0.0000	0.0000	0.0000

*Note: *, ** and *** indicate statistical significance at the probability levels of 10, 5 and 1 percent, respectively. Figures in the parentheses are standard errors, HHH is Household and TLU is Total Livestock Unit*

Favorable precipitation situation has significantly improved household's food security status by 39.11% under agronomic practices and 27.85% under small scale irrigation scenarios (see Table 18). This is more reasonable in Ethiopian agricultural system that is all most all hinges on natural rainfall. This is in line with previous studies (Abera *et al.*, 2011; Molua, 2002).

Furthermore, results showed positive association between climate adaptations options and household food security. Households who adopt agronomic practices, irrigation and soil and water conservation measures were found to be more food security than their counter parts (see Table 18). For instance adaptation of agronomic practice improves food security status by about 32% while SWC improved it by nearly 27%. Thus, adaptation strategies like crop diversification, use of modern varieties, irrigation and soil and water conservation strategies have become essential in climate risk reduction and food status enhancement. In contrast, we found the coefficient of livelihood diversification negative but statistically insignificant.

Among the other variables, age of household age and household size were found to have significant negative impact on household food security. Households with large size and more dependent family members were also more food insecure. These households need more resources, beyond what they produce, to fulfill their food needs. Negative impact of household size on food security is consistent with the finding of Shiferaw *et al.* (2005) and in contrast with the study by Abera *et al.* (2011). Level of education attained by household head was indicated to have positive relation with household's food security position. A study by Deressa and Hassan (2009) also found similar positive and significant impact. As expected, production input such as size of cultivated land held by the household was found to have a highly significant impact on household's food security. Furthermore, in line with prior expectation, household wealth indicators such as livestock possession influenced household food security status positively. Abera *et al.* (2011) founds similar result.

5.3.3 Impact of Climate Change Adaptation on Sesame Production

This study has tried to examine how sesame production is performing under the changing and variable climate in the study area. Does the changing climate brought opportunity or threat to sesame production? Were the sesame producers adopting sesame as an adaption option crop to climate change or are they giving up its production by opting for other crops? Additionally, we analyze the impact of the climate change adaptation strategies on the level of sesame production.

The study revealed that, in response to climate change, one of the main adaptation strategies sesame producers practice were agronomic practices. 36.25 percent of small holder typically adopted agronomic practices which encompass crop diversification, varying planting and harvesting dates, using drought tolerant and improved seeds. The sampled farmers were asked to list the five top crops they adopted in their crop diversification strategy response to the climate change. The result indicated that large number of farmers adopted Groundnut and Sesame crops as a response to climate change adaptation strategy. More than half (56.75%) of the smallholders adopted Groundnut while nearly half (42.50%) of them adopted Sesame as a main crop diversification practice in adjustment to climate change. Specifically, households were questioned if they adopt sesame as a diversification crop in response to the climate change and 41% of them responded positively.

Table 199: Crop diversification and trends of sesame production

In response to climate change, list the main crops you adopt to diversify your agricultural production	**Main crops**	**%**	**What is the pattern of the amount of sesame production over the last 10 years?**		**Main reasons**	**%**
	Maize	11.25%			no enough rain	3.25%
	Sorghum	12%			heavy rain	19.75%
	Groundnut	56.75%		Declining (93%)	off-season rain	26.50%
	Sesame	42.50%			diseases	58%
	others	32.25%			low price	33%
					others	27%

On the other hand, the farmers' were asked how they observed the trends sesame production over the last decades. Accordingly, nearly all smallholders (93%) revealed that the amount of sesame production over the last 10 years is declining. This was consistent with the declining national sesame production trends. The national data, according to CSA, 2017, indicated that over 2010-2016 periods average production growth rate declines by -35 percent (CSA, 2017).

The farmers' were also identified the main reasons to be directly related to the climate change and variability. 64.18% of the farmers mentioned climate factors (no enough rain, heavy rain, off-season rain and biotic diseases) as the main factor for the continuously declining amount of sesame production in the study area (see Table 19 above). This is in line with Kostka and Scharrer, 2011,study that showed that the sensitivity of sesame plant to weather hazards. Similarly, Sorsa, 2009, found that drought/inadequacy of rain as the most important sesame production problem.

Thus, if closely observed, one may see a paradox in the above results. If 93% percent of farmers said sesame production was declining due to largely (64.18%) climate factors, then how nearly half percent (42.50%) of them adopted sesame as a main crop diversification practice in adjustment to climate change (see Table 19 above)? To put it differently, how climate sensitive crop was adopted by nearly half of the farmers as an adaptation response to the climate change? We tried to grasp justification for this from FGDs carried out with different stakeholders. The result revealed that, though, sesame is climate sensitive crop the farmers have not been giving up on it due to the fact that it is high value crop. It was observed that, while few abounded it, large number of farmers keep sesame production but at a minimum level of production. If the production is successful they know that they will get high return from sesame sell as it is high market value crop. This indicated the risk-averse behavior of the farmers let them to reduce the amount of sesame production while the high value crop character of sesame holds them back from totally avoiding its production.

Further, we employed a truncated model to identify potential explanatory variables affecting household's level sesame production captured via size of land allocated to sesame production. Table 20 below presents both the parameter estimates and average marginal effect.

Table 200: Truncated Regression of determinants of intensity of sesame production

Land Sesame	Coef.	St.Err	Marginal Effects	Z-value
Agronomic practices	0.7951	0.4988	0.1707	1.68*
Livelihood diversification	0.8612	0.5367	0.1849	1.70*
Soil and water conservation	0.8996	0.4899	0.1932	1.94**
Small scale irrigation	1.2336	0.8614	0.2649	1.51
Sex	2.1116	0.8138	0.4534	2.80***

Education	0.1119	0.0651	0.0240	1.81**
Active family labor (AE)	0.0259	0.0587	0.0056	0.44
Number of Oxen	0.1344	0.1287	0.0289	1.03
Land total	0.1227	0.0694	0.0263	1.87**
Year Sesame	0.0346	0.0298	0.0074	1.18
Income livestock	0.0360	0.0230	0.0077	1.61
Food availability	0.8634	0.5137	0.1854	1.76*
Credit access	0.9770	0.4784	0.2098	2.20**
Social capital	-0.7064	0.5037	-0.1517	-1.45
Selling channels	0.5314	0.5842	0.1141	0.91
_cons	-8.8741	2.5346		0.00
/sigma	1.6104	0.2418		0.00
Mean dependent var		0.902	SD dependent var	0.914
Number of obs		281	Chi-square	24.615
Prob > chi2		0.055	Akaike crit. (AIC)	477.502
*** p<0.01, ** p<0.05, * p<0.1				

The results indicated that adopting climate adaptation measures have positive impact on level of sesame production. Adoption of agronomic practices, livelihood diversification and soil and water conservation strategies have improved the level of sesame production (see Table 20). Smallholders who implement agronomic practices like crop diversification, using drought-tolerant and modern varieties brings 0.171 hectare more land in to sesame production. Since the households may adopt sesame as a drought-resistant crop and may also use its improved varieties this would improve the whole level of sesame production. The study result indicated that 42.50% of households adopted sesame as a main crop diversification practice in adjustment to climate change (see Table 19 above). Other study also shows farmers adoption of sesame due to its drought and high thermal tolerance characteristics (USIAD, 2017).

Further, livelihood diversification has positively and significantly influenced level of sesame production. In contrary to our result, Wondimagegn,et al. 2011 indicated that off-farm income source negatively impacted farmers' farm involvement. But, in this case of sesame production non farm income source has positive influence possibly due to the high value crop character of sesame that the farmers may not abandon it easily. As expected, soil and water conservation practices has a significant ($p<0.05$) impact on the amount of sesame production where households who adapt this adaptation measure has 0.193 hectare additional land allocated

sesame production. This is reasonable because of SWC role in helping to mitigate flooding, soil erosion and conserve the little rain which in turn improves crop production. Studies revealed that, if the rain is over, floods are the major climate hazard to sesame in many ways (Kostka and Scharrer, 2011, USIAD, 2017). This showed SWC adaptation option is of high importance in boosting level of sesame production by curbing flooding and soil erosions. Among the other variables, sex of household, education, farm size, credit and food availability were found to have significant positive impact on the level of sesame productions. These are consistent with our earlier finding in chapter two (see Table 6).

5.4 Conclusion and Policy Implications

This study examined implication of climate change and adaptation strategies for sesame production and household food security in Western Ethiopia. Farm households in study area have faced climate change and variability, and have been adapting to it using different strategies. Though sesame production has been negatively impacted by climate changes, this study revealed that smallholders have kept sesame production mainly due to its high value crop character. Additionally, the study results from 2SLS estimation showed that increases in temperature and rainfall variability have significant negative effect on household food security. Further, results reveal that adaptation measures like agronomic practices, small-scale irrigation, and soil and water conservation have significantly improved household food security. Similarly, estimation from truncated model reveals that adaptation strategies have positively and significantly impacted level of sesame production. This suggests that adaptation strategies are effective both in ensuring household food security and improving level of sesame production.

Theses finding calls in policy and programs that promote and expand the practices of climate-change adaptation strategies based on the households' adaptive capacity. As rainfall variability is a critical constraint to household food security, risk reducing measures and programs would be helpful. Based on our finding, we further point toward policy that should target increasing provision of relevant timely information on current as well as future climate forecasts, introducing modern high yield and climate resilient crops. This would, in turn, will enhance farmers' climate adaptation decisions and help them reduce food insecurity in one hand and boost sesame production on the other hands.

Chapter Six

6. SYNTHESIS: SESAME PRODUCTION, CLIMATE CHANGE ADAPTATION AND FOOD SECURITY

The research presented in the four papers that form the core of this thesis has aimed to add an insights on an effort to address questions like: what are the key determinants of decision to participate in sesame production and level of sesame production; are farmers' exposed to climate change and variability and how have they respond to it; what are the status and determinants of farmers food security and, then, how did the climate change responses impacted farmers food security status and household level of sesame production. This synthesis provided an overview of lessons learned from the four central research findings- sesame production, exposure, adaptation, and food security- that are inherently interconnected in the context of changing climate. Next, the implications of this research work were presented based on four papers followed by suggestions for future research. The finally section highlights on the contribution of the research in terms of empirical, methodological and theoretical.

6.1. Sesame Production and Its Determinants

The second chapter of this thesis analyzed the determinant factors that influenced the smallholders' probability of participating in sesame production--one of the export potential cash crops--and its level of production. This enabled us to better understand the main factors influencing sesame production and recommend best adapted policy actions to tackle the problem deteriorating level of national sesame production. The results from the analyses of determinates of sesame production disclose that active family labor, total land holding, credit access, and food availability have positively and significantly influenced the probability of sesame production participation whereas access to off-farm activities has negative and significant effect (Paper one).

Our study proved that households' who have potential and experience in producing sufficient family food were the one found leading in intensifying sesame production. Farmers' access to credit for sesame production was also found to be critical factor in determining level of sesame production participation. The regression result further provided that access to market information

and sesame selling channel have had significant positive and negative effect on the level of sesame production, respectively (Paper one).This study vividly showed that sesame production decision was significantly constrained by farmers' resource endowment, institutional factors and availability of market information. We argue that future interventions that aimed at improving these constraints would be of paramount importance in commercializing and shifting rural farming in to export potential high value crops like-SESAME.

6.2. Climate Change Vulnerability, Adaptation Options and Its Determinants

The changing and variable climate has now creating difficulties to the rural poor smallholders' effort in overcoming poverty and food insecurity. We argue that assessing vulnerability, exploring adaptation options and investigating the variables of impact that determine farmer's decision to adopt adaptation options provides useful insights on farmers' decision. It is also helpful in designing effective incentive structures to overcome barriers to adaptation measures.

The finding of this study revealed that smallholder farmers are highly vulnerable or exposed to climate change and variability (Paper two). Most of the smallholders have experienced the disparity in rainfall and perceived the influences varying temperature over times. As a result, agriculture, the main source of the rural economy, has already been adversely affected. In recognition of the inevitable impacts of climate change, the study result showed that, there has been a growing practice of adapting different adaptation options among the smallholder farmers. The main adaptation strategies were broadly categorized in to, agronomic practices, livelihood diversification strategies, small-scale irrigation and soil and water conservation.

The examination of determinants of adaptation alternatives indicated that farmers' decision to implement adaptation options have been influenced by several factors. Agronomic practices was positively influenced by farm size, gender, social capital, and early warning information, number crop failures and negatively by the market distance. Adoption of livelihood diversification was impacted positively by the livestock possession and negatively by household head gender and education. The result further indicated that soil and water conservation practices were influenced by farm land size, early warning information and market distances. Moreover, the study result

showed that small-scale irrigation was positively influenced by education; social capital; and access to credit (Paper two). Generally, it was learned that the resource endowment enables farmers to implement adaptation decisions, which otherwise cause significant challenge to the practice of adaptation options. Though essentials, it was observed that lack of awareness about climate change, early warning systems and credit access as a key hurdle in the adaptation process. The role of access to market and appropriate sesame selling channels has found to be important in sustaining adaptation measures.

6.3. Climate Change Adaptation: Improved Food Security Status

In the third paper of this thesis, we carried out the analysis of the status and determinants of household food security under changing climate. We tried to identify the association of the major socio-economic, climatic and institutional factors with household food security. This was believed to be essential to better understand the main factors influencing household food security and recommend appropriate policy actions to tackle the problem. The results showed that only 65.8% of the sampled households were food secure. Additionally, the result revealed that productive farm assets – principally farm size and livestock owned were a critical factors determining household food security (Paper three).

Given the challenge posed by changing climate, there was a growing need to better understand the extent to which different adaptation options contribute to farmers' effort of achieving and enhancing food security. Our study has helped in not only identifying adaptation options but also understanding the role of these adaptation alternatives (Paper four). The result shows that climate change adaptation contributed to household food security status. Households adopting adaptation had higher food security level than the non-adapters. Specifically, result revealed that adaptation measures like agronomic practices, small-scale irrigation, and soil and water conservation have significant positive impact on household food security (Paper four). This indicates that in addition to reducing exposure to climate risks, climate change adaptation had significantly contributed to household food security. This is a good indication for the promotion of any efforts to plan and implement productive adaptation strategies to overcome climate risks.

6.4. Adaptation: Improved Sesame Production

Expanding our analysis we have made efforts to understand the relationship between sesame production, climate change and adaptation strategies. This would be helpful in well understanding how sesame production is performing under changing climate and pinpoints on how adaptation practices are affecting level sesame productions. Results from truncated model reveal that adaptation measures like agronomic practices, livelihood diversification and soil and water conservation have significant positive impact on household food security (Paper four). This made clear that adaptation strategies were useful both in improving level of sesame production by reducing risks pertaining to climate change. This study also found that households continue production and adoption of sesame, though it is climate sensitive crop in one way, due to its character of being high value and drought-tolerant crop (Paper four).

6.5. The Inter-Linkage

In general, the inter linkage between sesame production, climate change adaptation and food security under the changing climate can be depicted by the following diagram:

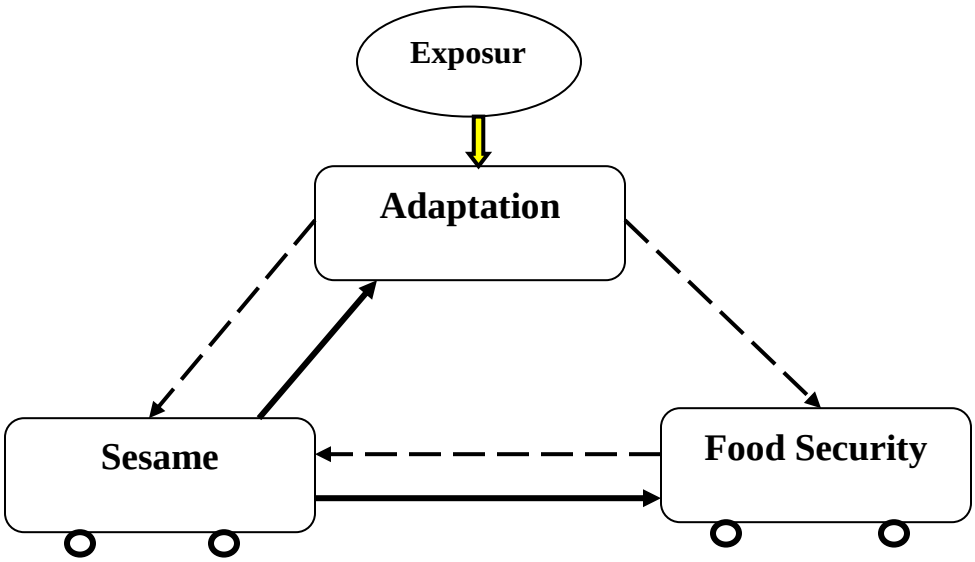


Figure 10 the Inter Linkage: sesame production, climate change adaptation and food security

The central theme of this research was to investigate the impact or role of adaptation to climate change measures practiced by smallholders on the sesame production and household food security status. It was to identify whether adaptation practices is really helping farmers improve their production and food security or not and if any, how. However, before diving unto adaptation impact analysis, we were expected to access the existence and extent of farmers' exposure to changing climate and examine adaptation practices going on in the study area and their determinants. Additionally, we studied food insecurity status of farmers and determinants of food security. Further, we had examined factor influencing farmers' decision to participate in sesame production and level of its production.

This study disclosed that there exist high climate change exposure in the study area and in response farmers' were taking different adaptation intervention adapt to the change. The intervention efforts were found to be essential in enhancing farmers' food security status and levels of sesame production. The improvement of food security, in turn, boosts farmers' involvement in cash crop (sesame) production. Our study proves that households' who have potential and experience in producing sufficient food for their families lead in intensifying sesame production. Consequently, from sesame production growth repercussion effect of profound importance bounce back to adaptation and food security. Since sesame is a high-value crop small improvement in production would result in high income return. This in turn, enhances farmers' involvement in adaptation practices and access to food by easing the liquidity constraints. For instance, this study reveals that having access to credit (liquidity) increases the probability of adoption of small-scale irrigation by 13.93%. This creates vital circle of inter-linkage and the interaction goes on.

6.6. Implications and Future Research

6.5.1. Implications

Contributions of the Study

Here under we discuss the knowledge and methodological contribution of this study. It contribute to the knowledge domain and methodological orientation on smallholders sesame production, exposure to climate change, the strategies they designed to adapt to the existing

change, and the impact of these adaptation measures on household food security and level of sesame production in three ways: empirical, methodological, and theoretical.

Empirically, the research contributes in documenting the contextual knowledge regarding the complex realities of farmer's sesame production, exposure to climate change, adaptation options and household food security in the study area. It discussed the main determinants of sesame production by smallholder farmers, their exposure to the changing climate and food security status, what mechanisms they are taking in response to the changes. This way, the research attempts to fill the knowledge gap in understanding the level of farmer's vulnerability and patterns of adaptation options that latter help to improve level of sesame production and household food security. The empirical finding shows main determinates and significant variations among smallholders in their decision to participate in sesame production, in their choice of adaptation options in response to adverse climate impacts, and the interaction between adaptation, sesame production and food security. We believe that the insights and observations coming out from the finding of this study would be helpful in forming bodies of knowledge on rural livelihood exposure, adaptation, sesame production and food security.

Methodologically, the research contributes in various forms to further analyze sesame production, climate exposure, adaptation and food security by: *Linking the context of climate exposure, adaptation and sesame production.* This study has attempted to assess the link among farmers' sesame production, climate exposure and adaptation responses, and then the impact of these responses on farmers' food security status and level of sesame production. As to my knowledge, no previous studies have attempted such analysis on this area. Theoretically, this study exerts efforts to assess and review the interface between sets of main theories and concepts that make the foundation of the research. This contributes a lot in framing the research to better understand the deviation and conjunction between theories and observations.

Policy Recommendations

In order to improve farmers' level of participation in production of market oriented cash crop production, more emphasis should be given to insuring farmers' food security all over the year. Our study proved that households' who have potential and experience in producing sufficient

family food were the one found leading in intensifying sesame production. It is, therefore, imperative to devise a policy that enhances farmers' food security in cash crop potential areas so as to enable them to fully engage in production of market oriented cash crop like sesame. There is also high possibility to improve sesame production participation and level of production by expanding provision of sesame specific credit mainly from formal sources. Having observed the vital role of access to price information and getting proper sesame selling channels, existence of effective sesame marketing system promotes households' to allocate more land to sesame production. In this regard, it needs intervention to solve input –output hurdles in sesame market mainly through provision of access to updated market price information and better selling channels.

The finding revealed that in order to adapt and reduce climate risks farmers are taking adaptation measures like agronomic practices, livelihood diversification, soil and water conservation and small-scale irrigation. The study result proved that adopting these adaptation options has contributed in reducing climate exposure by improving food security and level of sesame production. However, despite smallholders implementing a range of these adaptation options, their efforts are largely constrained by problems faced at each stage of decision-making. Thus, so as to reduce exposure to climate hazards, improve food security and sesame production by successfully applying adaptation options the policy makers should pay attention to: First, improving access to reliable climate forecast information and early warning systems is a key to facilities adaptation. Thus, timely provision of climate specific information could enhance preparedness of farm households to extreme events, and increasing farmer awareness to apply appropriate adaptation options on time. Second, it is of high importance to give emphasis to strengthen and expand infrastructural facilities such as access market, credit and cooperatives to improve farmers' adaptive capacity.

It is also observed that improved and drought tolerant crop varieties have the capacity to enhance household food security by off-setting the adverse effect of climate change. Therefore, in order to enhance farmers' climate change adaptation efforts, a policy to promote drought-tolerant crop varieties are of great importance. The study further reveal that though sesame is climate sensitive crop farmers continued to adapt it due to its high value return and drought-tolerance characters.

Therefore, in general, given the fact that adaptation enhances household food security and sesame production, it is imperative that future policy has to aim at devising and promoting viable projects on agronomic practices, livelihood diversification, soil and water conservation and small-scale irrigation adaptation measures that consider the availability of local smallholders resource endowments such as suitable land, water resources, labor, production inputs and capital resources.

6.5.2. Future Researches

This thesis looked into and discussed various related issues ranging from sesame production, vulnerability, adaptation, food security, to impact of adaptation on both food security and sesame production. Given the broadness of the areas, however, a lot remains to be done in this area. Having the finding of this thesis as a footing, we suggest further investigation in the following areas:

This study provided good insights on the determinants of a decision to participate in sesame production and level of sesame production. However, our observation showed that there is still little knowledge of how sesame value chain works in the study area. Though this study indicates that market variables are key determinants in sesame production, but how these factors are related to both producers and traders of sesame is still not clear enough. Thus, it is suggested that detail marketing analysis that would be adequate to capture the structure of sesame market are critical especially to avoid the unfortunate market biases against smallholder famers. With regard to the production part of value chain analysis, close specific analysis on the impact of climate factors are also important. We have observed farmers complaining about biotic stress and diseases that devastated their level of sesame production. Improving production and marketing chain of sesame, which is an export potential high value crop, would contribute a lot in bringing hardly earned foreign currency to the country and improving farmers food security status.

This study have tried to examine and evaluate the aggregate impact of agronomic practices, livelihood diversification, soil and water conservation and small scale irrigation climate change adaptation strategies on household food security and level of sesame productions. Nevertheless, the study is not in good enough position to providing sufficient information for a specific impact

of each adaptation options on household food security and level sesame production. Based on this result, it would be imperative if future research evaluate the disaggregated impacts of each adaptation option on household food security and level of sesame production in the study areas. This may contribute a lot in appropriately prioritizing adaptation options based on the potential benefits that each specific adaptation option would generate and the capacity to implement.

Further, the study was based on the information generated from the sample household survey during a single cropping season using across-sectional data. Hence, theoretical analyses of this research are largely based on static models, in which production, adaptation and adoption decision process treated as a static phenomenon and issues of expectations and dynamic adjustments would be overlooked. Though, incorporation of dynamics and expectations into tractable models is vital in agricultural and environmental research for the foreseeable future, the dynamic model avenue was not included in this research. It would be imperative if future research take on this broad venture.

References

Abebaw, S. (2003). Dimensions and determinants of food security among rural households in Dire Dawa, Eastern Ethiopia. MSc thesis, Alemaya University, Alemaya.

Abebaw, S., Janekarnkij, P., &Wangwacharakul, V. (2011). Dimensions of food insecurity and adoption of soil conservation technology in rural areas of Gursum District, Eastern Ethiopia. Kasetsart Journal of Social Sciences, 32(1), 308 – 318.

Abera B., Alwin K., Manfred Z. 2011. Using Panel Data to Estimate the Effect of Rainfall Shocks on Smallholders' Food Security and Vulnerability in Rural Ethiopia. Climate Change, 108:185–206

Adam B, Kassa B, Legesse B, Lemma T (2011). Determinants of Crop Commercial Orientation of Smallholder farm Households in Drought-prone areas of the Central Rift Valley of Ethiopia, Research Report. Addis Ababa: Ethiopia Institute of Agricultural Research.

Adger, W. (1999). Social Vulnerability to Climate Change and extremes in coastal Vietnam. World Development, 27(2), 249–269.

Adger, W. (2003). Social capital, collective action, and adaptation to climate change. Economics of Geography, 79(4), 387–404.

Adger, W. (2006). Vulnerability. Global Environmental Change, 16(3), 268–281.

Adger WN, Dessai S, Goulden M, Julme M, Lorenzoni I, Nelson DR, Naess LO, Wolf J, Wreford A (2009) Are there social limits to adaptation to climate change? Clim Change 93:335–354. doi:10.1007/s10584-008-9520-z

Adger, W., Kelly, PM. (1999). Social vulnerability to climate change and the architecture of entitlements. Mitigation and Adaptation Strategy Global Change, 4(3):253–266.

Aker, J. C. (2011). Dial "A" for agriculture: A review of information and communication technologies for agricultural extension in developing countries. Agricultural Economics, 42(6), 631–647.

Aklilu, A., &Alebachew, A. (2009). Assessment of climate change-induced hazards, impacts and responses in the southern lowlands of Ethiopia. Addis Ababa, Ethiopia.

Alebachew A (2011) Climate change and rural livelihoods in Northern Ethiopia. Impacts, local adaptation strategies and implications for institutional interventions. FSS Monograph No. 7. Forum for Social Studies, AAbaba

Alemu, D., G.W. Meijerink, 2010. The Ethiopian Commodity Exchange: an overview.

Ali A, Erenstein O (2017) Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan. Climate risk managment, 16:183-194

Altheide, D., & Johnson, J. (1994). Criteria for assessing interpretive validity in qualitative research. In N. Denzin & Y. S. Lincoln (Eds.), Handbook of Qualitative Research (pp. 485–499). Thousand Oaks, CA: Sage.

Aman Tufa, Adam Bekele and Lemma Zemedu (2014). 'Determinants of smallholder commercialization of horticultural crops in Gemechis District, West Hararghe Zone, Ethiopia'. African Journal of Agricultural Research. Vol. 9(3), pp. 310-319.

Amare A, Simane B (2017b) Convenient solution for convenient truth: adoption of soil and water conservation measures for climate change and variability in Kuyu District, Ethiopia. In: Leal Filho W et al (eds) Climate change adaptation in Africa, climate change management. Springer International Publishing, p 12.

Amsalu, A., & De Graaff, J. (2007). Determinants of adoption and continued use of stone terraces for soil and water conservation in an Ethiopian highland watershed. Ecological Economics, 61, 294 – 302, 61, 294–302.

Angrist J. D. 2001. Estimation of Limited Dependent Variable Models with Dummy Endogenous Regressors: Simple Strategies for Empirical Practice. Journal of Business and Economic Statistics, 19(1): 2-16

Angrist J. D. and Krueger A. B. 2001. Instrumental Variables and the Search for Identification: From Supply and Demand to Natural Experiments. Journal of Economic Perspectives, 15(4): 69-85

Anley, Y., Bogale, A., & 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.

Arega, B., Woldeamlak, B., & Melanie, N. (2013). Rural households' livelihood assets, strategies and outcomes in drought-prone areas of the Amhara Region, Ethiopia: Case Study in Lay Gaint District. African Journal of Agricultural Resources, 8(46), 5716–5727.

AregaDemelash and Rashid, M. 2005. The efficiency of traditional and hybrid maize production in eastern Ethiopia: An extended efficiency decomposition approach. Journal of African Economies, 15(1): 91-116.

Arndt, C., Robinson, S., &Willenbockel, D. (2011). Ethiopia's growth prospects in a changing climate: A stochastic general equilibrium approach. Global Environmental Change, 21, 701–710.

Asfaw, A., &Admassie, A. (2004). The role of education on the adoption of chemical fertilizer under different socioeconomic environments in Ethiopia. Agricultural Economics, 30(3), 215–228.

Asfaw S, Shiferaw B, Simtowe F, Lipper L (2012) Impact of modern agricultural technologies on smallholder welfare: evidence from Tanzania and Ethiopia. Food Policy 37(3):283–295

Asfaw S, Coromaldi M, Lipper L (2015) Adaptation to climate risk and food security: evidence from Ethiopia

Ashfaq, M., S. Hassan, Z.M. Naseer, A. Baig, and J. Asma. 2008. Factors affecting farm diversification in rice-wheat. Pakistan Journal of Agricultural Sciences, 45(3): 45-47.

Asrat, P., Kassa, B., &Hamito, D. (2004). Determinants of farmers' willing to pay for soil conservation practices in the southern highlands of Ethiopia. Land Degradation and Development, 15, 423–438.

ATA, 2015. Sesame Value Chain Development Strategy (Working Document 2015-2019), Addis Ababa, Ethiopia

Awulachew SB, Merrey DJ, Kamara AB, et al (2005) Experiences and opportunities for promoting small-scal irrigation and rainwater harvesting for food security in Ethiopia. IWMI, Colombo, Sri Lanka

Ayalew, Y. (2003). Identification and intensity of food insecurity and coping strategies of rural households in North Shoa: The case of Lalomama. MSc thesis, Alemaya University.

Balew, S., Agwata, J., &Anyango, S. (2014). Determinants of adoption choices of climate change adaptation strategies in crop production by small scale farmers in some regions of Central Ethiopia. Journal of Natural Sciences Research, 4(4), 78–93.

Barrett, C. (2002). Food security and food assistance programs. Handbook of agriculturaleEconomics (Volume 2). Amsterdam: Elsevier Science.

Barrett, C. B. (2010). Measuring food insecurity. Science, 327, 825–828.

Bayard, B., Jolly, C., & Shannon, D. (2007). The economics of adoption and management of alley cropping in Haiti. Journal of Environmental Management, 84, 62–70.

Bazezew A, Bewket W, Nicolau M. 2013, Rural households livelihood assets, strategies and outcomes in drought-prone areas of Ethiopia: Case Study in Lay Gaint District. African J Agric Res.8(46):5716–27.

Beddington J. et al. (2012) Achieving food security in the face of climate change: final report from the commission on sustainable agriculture and climate change.

Bekele, W., & Drake, L. (2003). Soil and water conservation decision behavior of subsistence farmer s in the Eastern Highlands of Ethiopia: a case study of the Hunde-Lafto area. Ecological Economics, 46(3), 437–451.

Belay, A., Recha, J., Woldeamanuel, T., & Morton, F. (2017). Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. Agriculture & Food Security, 6(24), 1–13.

Belayneh, L. (2005). Analysis of food insecurity Causes: The case of rural Mete Woreda, Eastern Ethiopia. MSc thesis, Haramaya University.

Below, T., Mutabazi, K., Kirschke, D., Franke, C., Sieber, S., Siebert, R., &Tscherning, K. (2012). Can farmers' adaptation to climate change be explained by socio-economic household-level variables? Global Environmental Change, 22, 223–235.

Benhin JKA (2008) South African crop farming and climate change: An economic assessment of impacts. Glob Environ Chang 18:666–678. doi: http://dx.doi.org/10.1016/j.gloenvcha.2008.06.003

Benin, S., Smale B., M., Pender, J., GebremedinBerhanu and Ehui, M. S. 2004. Determinants of cereal crop diversity on farms in the Ethiopian highlands. Journal of Agricultural Economics, 31(2-3): 197-208.

Berger, P., &Luckmann, T. (1966). The social construction of reality: A treatise in the sociology of knowledge. Garden City, NY: Doubleday.

Berry, PM., Rounsevell, MA., Harrison, PA., Audsley, E. (2006). Assessing the vulnerability of agricultural land use and species to climate change and the role of policy in facilitating adaptation,. Environmental. Science and. Policy, 9, 189–204.

Bewket, W. (2012). Climate change perceptions and adaptive responses of smallholder farmers in central highlands of Ethiopia. Journal of Environtal Studies, 69(3), 507–523.

Bewket, W., Radeny, M., & Mungai, C. (2015). Agricultural adaptation and institutional responses to climate change vulnerability in Ethiopia. (No. 106). Copenhagen, Denmark. Retrieved from www.ccafs.cgiar.org

Beyene, F. (2014). Determinants of food security under changing land-use systems among pastoral and agro-pastoral households in eastern Ethiopia. Environmental Development and Sustainability, 17 (5): 1163-82.

Beyene, F., &Muche, M. (2010). Determinants of food security among rural households of central Ethiopia : An empirical analysis. Quarterly Journal of International Agriculture, 49(4), 299–318.

Boardman, M. (2002). Seasonal rural household food insecurity in Zambia: A case study of Mutanda. MapplSc. Massey University,Palmerston North.

Bogale, A., &Shimelis, A. (2009). Household level determinants of food insecurity in rural areas of Dire Dawa, Eastern Ethiopia. African Journal of Food, Agriculture, Nutrition and Development, 9(9), 1914–1926.

Boserup, E. (1965). The conditions of agricultural growth: The economics of agrarian change under population pressure. London: Earth scan Publications Ltd.

Boughton D., Mather.D, Barrett.C, Benfica R., Abdula D., Tschirley.D and Cunguara. B, (2007); "Market Participation by Rural Households in a Low-Income Country: An Asset-Based Approach Applied to Mozambique;" Faith and Economics Vol 50: 64-101

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

Brown DR, Ouma JO, Barrett CB. Livelihood strategies in the rural Kenyan highlands. African Jounrnal Agric Res Econ. 2006;1(1):21–36.

Bryan, E., Deressa, T., Gbetibouo, G., & Ringler, C. (2009). Adaptation to climate change in Ethiopia and South Africa: options and constraints. Environmental Science and Policy, 12(4), 413–426.

Bryant, C., Smit, B., Brklacich, M., Johnston, T., Smithers, J., Chiotti, Q., & Singh, B. (2000). Adaptation in Canadian agriculture to climatic variability and change. Climate Change, 45, 181–201.

Burke,W. 2009.Triple hurdle model of smallholder production&market participation in Kenya's dairy s. MSc thesis.

Burke, M., & Lobell, D. (2010). Food security and adaptation to climate change: What do we know? In L. D & B. M. (eds.) (Eds.), Climate Change and Food Security.

Byerlee, D. Spielman, D.J., Dawit Alemu and Gautam, M. 2007. Policies to Promote Cereal Intensification in Ethiopia: A Review of Evidence and Experience. IFPRI Discussion Paper 00707, International Food Policy Research Institute, 2033 K Street, NW, Washington, DC 20006-1002, USA.

Cadot, O., L. Dutoit and M. Olarreaga (2006); How Costly Is It for Poor Farmers to LiftThemselves Out of Subsistence? World Bank Policy Research Working Paper 3881

Carney, D. (1998). Sustainable rural livelihoods: What contribution can we make? London.

Carney, D., Drinkwater, M., Rusinow, T., Neefjes, K., Wanmali, S., & Singh, N. (1999). Livelihoods approaches compared: a brief comparison of the livelihoods approaches of the UK department for international development (DFID) CARE, Oxfam and the United Nations Development Programme (UNDP). London.

Carter, T., Parry, M., Nishioka, S., &Harasawa, H. (1994). Technical guidelines for assessing climate change impacts and adaptations. Report of working group II of the intergovernmental panel on climate change. London, UK and Tsukuba, Japan.

Casebeer, A., & Verhoef, M. (1997). Combining qualitative and quantitative research methods: Considering the possibilities for enhancing the study of chronic diseases. Chronic Diseases in Canada, 18, 130–135.

Challinor, A. J., Ewert, F., Arnold, S., Simelton, E. and Fraser, E. (2009). Crops and climate change: progress, trends, and challenges in simulating impacts and informing adaptation. J. Exp. Bot., 60, 2775–2789.

Chambers, R. (1992). Participatory rural appraisal. UK: University of Sussex.

Christiaensen L, Demery L, Kuhl J (2011) The (evolving) role of agriculture in poverty reduction: an empirical perspective. J Dev Econ 96(2):239–254

Christina, H., Thomson, M., Jennifer, S., & Anderson, S. (2001). Addressing food security in Africa via multiple livelihood strategies of women farmers. Journal of Food Policy, 26(1), 177–207.

Cheru, F. (1989). The silent revolution in Africa: Debt, development and democracy. Harare and London: Anvil Press and Zed Press.

Coates, M., R. Kitchen, G. Kebbell, C. Vignon, C. Guillemain, R. Hofmeister, 2011. Financing Agricultural Value Chains in Africa. Focus on Coffee and Sesame in Ethiopia. GIZ Bonn and Eschborn, Germany

Coleman, J. . (1998). Social capital and the creation of human capital. American Journal of Sociology, 94, 95–120.

Conway D (2011) Adapting climate research for development in Africa. Wiley Interdiscip Rev Clim Chang 2:428–450

Conway, D., & Schipper, E. L. F. (2011). Adaptation to climate change in Africa: Challenges and opportunities identified from Ethiopia. Global Environmental Change, 21(1), 227–237.

Cragg, J. (1971). Some statistical models for limited dependent variables with application to the demand for durable goods, Econometrica 39, 829-844.

CSA (Central Statistical Agency) (2009). 'Statistical report on area and production of crops'. Addis Ababa, Ethiopia.

CSA (2009) Area and Production of Crops (Private Peasant Holders, Mehr Season), Addis Ababa. 1–128.

CSA, 2010.Agricultural Sample Survey 2010/2011.Area and production of crops.CSA of Ethiopia, Addis Ababa.

CSA (Central Statistical Agency).2014.Agricultural Sample Survey for 2013/14 Crop Season. Volume V. Report on Area, Production and Farm Management Practice of Crops for Private Peasant Holdings (Belg Season).Statistical Bulletin 532. FDRE/CSA, Addis Ababa, Ethiopia.

CSA, 2009-2014. Agricultural Sample Survey (2009/10-2013/14). Report on Area and Production of Major Crops for Private Peasant Holdings, Meher Season. Addis Ababa.

Damena, D. (2012). Determinants of farmers' land management practices: The case of Tole District, South West Shewa Zone, Ethiopia. Journal of Sustainable Development in Africa, 14(1), 76–96.

Dasgupta, P., J.F. Morton, D. Dodman, B. Karapinar, F. Meza, M.G. Rivera-Ferre, A. ToureSarr and KEV, 2007 Rural areas. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge; 996pp p.

Datta, L. (1994). Paradigm wars: A basis for peaceful coexistence and beyond. In C. M. Rechardt& S. Rallis (Eds.), The qualitative- quantitative Debate: New perspectives. San Francisco: Jossey-Bass, pp.53-70.

Dawson N, Martin A, Sikor T (2016) Green revolution in Sub-Saharan Africa: implications of imposed innovation for the wellbeing of rural smallholders. World Dev 78:204–218

Davis, R. S. (2008). Conditional Preemption, Commandeering, and the Values of Cooperative Federalism: An Analysis of Section 216 of EPAct. Columbia Law Review, 404–451. http://www.jstor.org/stable/40041761.

Debalke, N. M. (2014). Determinants of farmers' preference for adaptation strategies to climate change: Evidence from north Shoa zone of Amhara region Ethiopia. American Journal of Social Sciences, 2(4), 56–66.

Degefe B (2002) Annual Report on the Ethiopian Economy. Ethiopian Economic Association, Addis Ababa, Ethiopia

Degefa, T. (2002). "Household seasonal food insecurity in Oromiya Zone, Ethiopia: Causes" (No. 26). Addis Ababa, Ethiopia.

Demeke, Keil, & Zeller. (2011). Using panel data to estimate the effect of rainfall shocks on smallholders food security and vulnerability in rural Ethiopia. Climate Change, 108(1), 185–206.

Dercon, S. (2004). Growth and Shocks: Evidence from Rural Ethiopia." Journal of Development Economics, 74(2):309–329.

Dercon, S. 2005. Risk, Poverty and Vulnerability in Africa" Journal of African Economies, 14(4):483-488.

Deressa, T. (2007). Measuring the impact of climate change on Ethiopian agriculture: Ricardian approach, policy research working paper; No. 4342. World Bank, Washington DC, World Bank.

Deressa T. and Hassan R. 2009. Economic Impact of Climate Change on Crop Production in Ethiopia: Evidence from Cross-section Measures. Journal of African Economies 18 4:529–554.

Deressa, T., Yesuf, M., Hassan, M., Claudia, R., &Tekie, A. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. Global Environmental Change, 19(2), 248–255.

Deressa, T., Hassan, R,,& Ringler C. (2011). Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. Journal of Agricultural Science, 49, 23–31.

Deressa, T., Yehualashet, H., &Rajan, D. S. (2014). Climate change adaptations of smallholder farmers in South Eastern Ethiopia. Journal of Agricultural Extension and Rural Development, 6(11), 354–366.

Devereux, S. (1988). Entitlements, availability and famine:A revisionist view of Wello, 1972- 74". Food Policy, 13(3).

Devereux, S. (1993). Theories of famine. New York: Harvester Wheatsheaf.

Devereux, S. (2000). Famine in the twentieth century" (No. 105). Brighton.

Devereux, S. (2002). Introduction: The "new famines" (1 No. 33).

Devèze J-C (2011) Challenges for African Agriculture: African Development Forum The World Bank. 1818 H Street NW, Washington, DC, USA

Di Falco, S., Veronesi, M., &Yesuf, M. (2011). Does daptation to climate change provide food security?. American Journal of Economics, 93(3), 829–846.

Di Falco S., Yesuf M, and Kohlin G. 2011c. What Adaptation to Climate Change? Evidence Climate Change in Low-Income Countries. Ethiopian Development Research Institute and International Food Policy Research Institute, Washington, DC

Dikito, M. . (2001). Social capital: Empowering women to achievefFood security. International food policy research institute (IFPRI) (12 No. 9). Washington DC, USA,.153

Dolisca, F., Carter, R., McDaniel, J., Shannon, D., & Jolly, C. (2006). Factors influencing farmers' participation in forestry management programs: A case study from Haiti. Forest Ecology and Management, 236, 324–331.

Dorfman, J. (1996). Modeling multiple adoption decisions in joint framework. American Journal of Agricultural Economics, 78, 547–557.

Dorward, A., Poole, N., Morrison, J., Kydd, J., & Urey, I. (2003). Markets, institutions and technology: Missing links in livelihood analysis. Development Policy Review, 21(3), 319–332.

Downing, T. (1992). Climate Change and Vulnerable Places: Global food security and country studies in Zimbabwe, Kenya, Senegal and Chile. Environmental Change Unit (ECU).

Dzanku FM, Jirström M, Marstorp H (2015) Yield gap-based poverty gaps in rural Sub-Saharan Africa. World Dev 67:336– 362

Dzanja, J., Christie, M., Fazey, I., & Hyde, T. (2015). The role of social capital in rural household food security : The case study of Dowa and Lilongwe Districts in Central Malawi. Journal of Agri'al Science, 7(12), 165–176.

Eakin, H., Luers, A.L. (2006). Assessing the vulnerability of social–environmental systems. Annual Review of Environment and Resources, 31, 365–394.

Edriss, A.K and Simtowe, F. 2002.Technical Efficiency in Groundnut Production in Malawi: An Application of a Frontier Production Function. UNISWA Research Journal of Agriculture, Science and Techn'gy 6(1):45-50.

Ellis F, Freeman HA (2004) Rural livelihoods and poverty reduction strategies in four African countries. J Dev Stud 40(4):1–30

EPCC. (2015). First assessment report, working group II agriculture and food security. Addis Ababa: Ethiopian Panel on Climate Change (EPCC), Ethiopian Academy of Sciences.

ERCA, 2009-2013. Ethiopian revenue and customs authority import export data.

Ericksen, PJ. (2008). Conceptualizing food systems for global environmental change research. Global Environmental Change, 18(1):234–245.

Eshete, B. (2007). Livelihood strategies of smallholder farmers and income poverty in draught prone areas: The case of Gena- Bosa woreda, SNNPRS. Haramaya University.

Fankhauser, S. (1996). The potential costs of climate change adaptation. In J. Smith, N. Bhatti, G. Menzhulin, R. Bennioff, M. Budyko, M. Campos, F. Rijsberman (Eds.), Adapting tocClimate change: An international perspective. New York: Springer, pp. 80–96.

FAO. (1996a). Rome declaration on world food security and world food summit plan of action. Rome.

FAO. (1996b). Socio-political and economic environment for food security, world food summit.

FAO. (2007b). The social dimension of adaptation to climate change in Ethiopia. Discussion paper 14. The World Bank, Wahington, DC.

FAO. (2010). The state of food insecurity in the world. Addressing food insecurity in protracted crises. Rome.

FAO (2011) Save and grow: a policymaker's guide to the sustainable intensification of smallholder crop production. Food and Agriculture Organization of the United Nations, Rome.

Food and Agriculture Organization of the United Nations.(2012). Sustainable Crop Production Intensification. Twenty-third Session. FAO, Rome.

FAOSTAT of the United Nations, 2002-2017. "Production Crops: sesame seeds". Government of Ethiopia, Growth and Transformation Plan II, 2015

FAO, 2015. Regional overview of food insecurity: African food security prospects brighter than ever. FAO, Accra Strategic Survey.

FAO. 2015. Analysis of price incentives for Sesame seed in Ethiopia, 2005-2012. Technical notes series, MAFAP, by Kuma Worako,T., MasAparisi, A., Lanos, B., Rome.

FAO. (2017). Regional overview of food security and nutrition in Africa 2016. The challenges of building resilience to shocks and stresses. Accra.

Fassil, K. (2005). Enough with famines in Ethiopia: A clarion call. Addis Ababa. Addis Ababa: Commercial Printing Enterprise.

FDRE (Federal Democratic Republic of Ethiopia). (2011). Ethiopia's climate-resilient green economy: Green economy strategy. Addis Ababa, Ethiopia.

Fetien, A., Bjornstad, A. and Smale, M. 2009. Measuring on farm diversity and determinants of barley diversity in Tigray, northern Ethiopia. Momona Ethiopia Journal of Science, 1(2): 44-66.

Field CB, Barros VR, Dokken DJ, et al (2014) INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE Drafting IPCC, 2014: Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report. 1–2.

FIVIMS. (2002). Measurement and assessment of food deprivation and undernutrition. Rome.

Francesco, G. 1999. Agricultural Diversification and Rural Industrialization as a Strategy for Rural Income Growth and Poverty Reduction in Indochina and Myanmar. Markets and Structural Studies Division, International Food Policy Research Institute, 2033 K Street N.W. Washington, D.C.

Funk, C., Michaelsen, J., Marshall, M., 2012. Mapping recent decadal climate variations in precipitation and temperature across Eastern Africa and the Sahel, chap. 14 of Remote sensing of drought—Innovative monitoring approaches: Wardlow, B., Anderson, M., and Verdin, J., eds., New York, CRC Press, 484 p.

Gbetibouo, G. . (2009). Understanding farmers' perceptions and adaptations to climate change and variability: The case of the Limpopo Basin, South Africa. Washington DC.

Gebrehiwot T, Veen A, Maathuis B (2011) Spatial and temporal assessment of drought in the Northern highlands of Ethiopia International. J Appl ObsGeoinf 13(3):309–321. doi:10.1016/j. jag.2010.12.002

Gebrehiwot, T., & Veen, A. van der. (2013). Farm level adaptation to climate change: The case of farmer's in the Ethiopian highlands. Environmental Management, 52, 29–44.

Gebrehiwot, T., & Van Der Veen, A. (2014). Climate change vulnerability in Ethiopia: disaggregation of Tigray Region. Journal of Eastern African Studies, 7(4), 607–629.

Gebrehiwot T, Anne Van Der V (2015) Estimating the impact of food security program by propensity score matching. J Dev Agric Econ 7(1):38–47

Gebremedhin B, Jaleta M, Hoekstra D (2009) Smallholders, institutional services, and commercial transformation in Ethiopia. Agric Econ 40:773–787. doi: 10.1111/j.1574-0862.2009.00414.x

Gebreyesus SH, Lunde T, Mariam DH, Woldehanna T, Lindtjørn B. 2015 Is the adapted Household Food Insecurity Access Scale (HFIAS) developed internationally to measure food insecurity valid in urban and rural households of Ethiopia? BMC Nutr Jan;1(1):2.

Gebreyesus, B. (2016). Determinants of livelihood diversification: The case of KembataTambaro Zone, Southern Ethiopia. Journal of Poverty, Investment and Development, 23, 1–10.

Gemechu, F., Zemedu, L., & Yusuf, J. (2016). Determinants of farm household food security in HawiGudina district, West Hararghe zone, Oromia Regional National State, Ethiopia. Journal of Agricultural Extension and Rural Development, 8(2), 12–18.

Gizachew L, and Shimelis A, 2014 Analysis and mapping of climate change risk and vulnerability in Central Rift Valley of Ethiopia. Afr Crop Sci J. 22(Issue Supplement s4):807–18.

Goletti, F., Rich, K. and Wheatley, C. 1998. Starch Industry Development as A Strategy for Agro-food Based Rural Industrialization in Vietnam, International Food Policy Research Institute, Washington, D.C.

Govereh, J., & Jayne, T. (2003). Cash cropping and food crop productivity: synergies or tradeoffs? Agricultural Economics, 28(1), 39-50.

Gray, C., & Mueller, V. (2012). Drought and population mobility in rural Ethiopia. World Development, 40(1), 134–145.

Greene W. Econometric analysis. 4th ed. New Jersey: Prentice-hall Inc; 2000.

Gregory, J. P., Ingram, S. J., &Brklacich, M. (2005). Climate change and food security. Philosophical Tranzaction of the Royal Society, 360, 2139–2148.

Guba, E., & Lincoln, Y. (1994). Competing paradigms in qualitative research. In N. K. Denzin & Y. Lincoln (Eds.), Handbook of Qualitative Research (pp. 105–117). Thousand Oaks, CA: Sage.

Gujirati DN 1995. Basic Econometrics, 3rd ed.. New York: McGraw-Hill Co. Science.

Gujarati, D. (2004). Basic Econometrics, 4th ed. The McGraw Hill Companies.

Haase, J., & Myers, S. (1988). Reconciling paradigm assumptions of qualitative and quantitative research. Western Journal of Nursing Research, 10, 128–137.

Hadleya, C., Linzerb, D. A., Tefera, B., Abebe, G., Fasil, T., &Lindstrome, D. (2011). Household capacities, vulnerabilities and food Insecurity: shifts in food insecurity in urban and rural Ethiopia during the 2008 food crisis. Social Science and Medicine, 73(1), 1534–1542.

Haile, H. K., Alemu, Z. G., &Kudhlande, G. . (2005). Causes of household food insecurity in Koredegaga Peasant Association, Oromiya Zone, Ehiopia. Agricultural Economics Research, Policy and Practice in Southern Africa, 44(4), 543–560.

Hassen Beshir, BezabehEmana, Belay Kassa and Jema Haji. 2012. Determinants of chemical fertilizer technology adoption in north estern highlands of Ethiopia: The double hurdle approach. Journal of Research Economics and International Finance, 1(2): 39-49.

Hassan, R., &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.

Hastenrath, S., Polzin, D., Mutai, C.C., 2007. Diagnosing the 2005 Drought in equatorial East Africa. J. Clim. 20, 4628–4637.

Healy, F. J. (1984). Statistics: A Tool for Social Research. Wads Worth Publishing Company, California.

Henderson, J. Baylis, K., and Barton, J., (2010). Conversion from Staples to Cash Crop Production in Mexico After NAFTA: Effects of PROCAMPO and Credit Constraints. Denver, Colorado, July 25-27, 2010

Hertel, T.W., Rosch, S.D., 2010. Climate change, agriculture and poverty. Policy Research Working Paper 5468. Washington, DC, World Bank.

Hoddinott, J. (1999). Operationalizing household food security in development projects: An introduction (Technical Guide 1). Washington D.C.: International Food Policy Research Institute (IFPRI).

Holden, S., & Shiferaw, B. (2004). Land degradation, drought and food security in a less favored area in the Ethiopian highlands: a bio-economic model with market imperfections. Agricultural Economics, 30(1), 31–49.

Hosmer, D. W., &Lemeshew. (1989). Applied logistic regression. New York.: A Wiley. Inter-science Publication.

Hughes, A., Morris, C., & Seymour, S. (2000). Introduction. In A. Hughes, C. Morris, & S. Seymour (Eds.), Ethnography and rural research. Cheltenham: Countryside Community Press,pp.1-27.

Humpheys, RB. (2010); Dealing With Zeros in Economic Data, December 14, 2010.

Hussain, I., Regassa, N., &Madar, S. (2004). Water for food security for the poor. Sri lanka: Asian Development Bank. Colombo.

Ibrahim, H., Rahman, S.A., Envulus, E.E. and Oyewole, S.O. 2009. Income and crop diversification among farming households in a rural area of north central Nigeria. Journal of Tropical Agriculture, Food and Environment Extension, 8(2): 84-89.

IFAD (International Fund for Agricultural Development) (2011) Rural poverty portal.

IIRR. (2007). Leaving disasters behind: A guide to disaster risk reduction in Ethiopia. Addis Ababa, Ethiopia.

IPCC. (2007a). Climate change 2007: Impacts, adaptations and vulnerability. Contribution of working group II to the third assessment report of the intergovernmental panel on climate change. Cambridge: Cambridge University Press, pp.1000.

IPCC, 2007b. Climate Change Impacts, Adaptation and Vulnerability-Working Group II Contribution to the Intergovernmental Panel on Climate Change: Summary for Policymakers. IPCC Secretariat, Geneva, Switzerland.

IPCC (2011). Managing the risks of extreme events and disasters to advance climate change adaptation: Special report of Intergovernmental Panel on Climate change (IPCC).

IPCC. (2014). Climate change 2014: Impacts, adaptation, and vulnerability. Part A: global and sectoral aspects. In C. B. Field, T. V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, & L. L. W. (Eds.), Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change (p. 113). Cambridge and New York: Cambridge University Press.

IPCC (2018) Special Report on Global Warming: the intergovernmental panel on climate change, 2018/24/PR IPCC PRESS RELEASE, October 2018.

Israel, GD. (1992). Determining sample size: Fact sheet PEOD-6, University of Florida.

Jayne, T. (1994). Do High Food Marketing Costs Constrain Cash Crop Production? Evidence from Zimbabwe. Economic Development and Cultural Change, 42(2), 387–402.

Jennifer Coates, Swindale A, Bilinsky P. 2007 Food and Nutrition Technical Assistance Project (FANTA) Academy for Educational Household Food Insecurity Access Scale (HFIAS) for Measurement of Food Access: Indicator Guide VERSION 3.

Jon, P. 2007. The adoption and productivity of modern agricultural technologies in the Ethiopian highlands: a cross-sectional analysis of maize production in the west Gojam zone, Proceeding of the 2nd International Symposium on Economic Theory, Policy and Applications, 6-7th August 2007. Athens, Greece.

Kahiluoto, H., Rimhanen, K., Rötter, R., Tseganeh, B., &Kahiluoto H, Rimhanen K, Ro¨tter R, T. B. (2012). Mitigation of climate change to enhance food security: an analytical framework. Forum Devevelopment Studies, 39, 51–73.

Kandlinkar, M., &Risbey, J. (2000). Agricultural impacts of climate change: If adaptation is the answer, what is the question? Climatic Change, 45, 529–539.

Kang Y, Khan S, Ma X (2009) Climate change impacts on crop yield, crop water productivity and food security – A review. Prog Nat Sci 19:1665–1674. doi: http://dx.doi.org/10.1016/j.pnsc.2009.08.001

Kassa, Y., Haji, J., &Legesse, B. (2013). Impact of integrated soil and water conservation program on crop production and income in West Harerghe Zone, Ethiopia. International Journal of Environmental Monitoring and Analysis, 1(4), 111–120.

Kedir AM (2005) Estimation of Own- and Cross-price Elasticities using Unit Values: Econometric Issues and Evidence from Urban Ethiopia. J Afr Econ 14:1–20. doi: 10.1093/jae/ejh030

Kelejian H. H. 1971. Two-Stage Least Squares and Econometric Systems Linear in Parameters but Nonlinear in the Endogenous Variables. Journal of the American Statistical Association Vol. 66, No. 334: pp. 373- 374

Kelly, P., &Adger, W. (2000). Theory and practice in assessing vulnerability to climate change and facilitating adaptation. Climatic Change, 47(4), 325-352.

Kidane, G., Abebe, T., &Degefie, T. (2006). Estimating crop water use and simulating yield reduction for maize and sorghum in Adama and Miesso districts using the cropwat model. (No. 31). Pretoria.

King, G., Keohane, R., &Verba, S. (1994). Designing social inquiry: Scientific inference in qualitative research.

King RP.2007. Agricultural cooperatives II: Can they facilitate access of small-scale farmers in South Africa to input and product markets? AU - Ortmann, G F. Agrekon. 46(2):219–44.

Kostka, G. and J.Scharrer. 2011. Ethiopia's sesame sector: The contribution of different farming models to poverty alleviation, climate resilience and women's empowerment. Oxfam Research Reports. 45p.

Kothari, C. R. (2004). Research methodology: Methods and techniques. New Delhi, India.: New Age International (P), Ltd.Publishing.

Kurukulasuriya, P., & Mendelsohn, R. (2008). A ricardian analysis of the impact of climate change on African cropland". Ican Journal of Agricultural and Resource Economics, 2(1), 1–23.

Kuzel, A., & Like, R. (1991). Standards of trustworthiness for qualitative studies in primary care. In P. Norton, M. Steward, F. Tudiver, M. Bass, & E. V. Dunn (Eds.), Primary Care Research. (Newbury Pa, pp. 138–158).

Latif, M., Dommenget, D., Dima, M., 1999. The role of Indian Ocean sea surface temperature in forcing east African climate anomalies during winter 1998. J. Clim. 12, 3479–3504.

Leary, N. (1999). A framework for benefit-cost analysis of adaptation to climate change and climate variability. Mitigation and Adaptation Strategies for Global Change, 43(3), 307–318.

Lencha BK (2008) Water use efficiency of smallholder irrigation in the Ethiopian Central Rift Valley The case of HalekuMelka-Tesso irrigation project: Internship report to Irrigation and Water Engineering Group , Wageningen University.

Little, P. D., Stone, M. R., Mogues, T., Catro, A. P., &Negatu, W. (2006). Moving in place: Drought and poverty dynamics in south Wollo, Ethiopia. Journal of Development Studies, 42(2), 200–225.

Lipton, M. (2005). The family farm in a globalizing world: The role of crop science in alleviating poverty (No. 41). Washington, D.C.

Lobell DB et al (2008) Prioritizing climate change adaptation needs for food security in 2030. Science 319:607–610

Lukanu G; Maryann, Green; Peter, Greenfield & Steve, Worth (2004): Farmers' cash crop cultivation decisions in Southern Niassa province, Mozambique, Development Southern Africa, 21:3, 531-554

Maddala, G. S. (1981). Introduction to econometrics: Business economics (2nd ed.). New York: Florida University, Macmillan.

Maddison, D. (2006). The perception of and adaptation to climate change in Africa (No. 10). Pretoria, South Africa.

Makombe, G., Kelemework, D., &Aredo, D. (2007). A comparative analysis of an irrigated agricultural productionin Ethiopia. Irrigation and Drainage Systems, 21(1), 35–44.

Malthus, T. (1960). Essay on population (3rd ed.). New York.: Random House.

Maskrey, A., Buescher, G., Peduzzi, P., Schaerpf, C., 2007. Disaster Risk Reduction: 2007 Global Review. Consultation Edition. Prepared for the Global Platform for Disaster Risk Reduction First Session, Geneva, Switzerland, pp. 5–7.

Matouš P, Todo Y, Mojo D (2013) Roles of extension and ethno-religious networks in acceptance of resource-conserving agriculture among Ethiopian farmers. Int J Agric Sustain 11:301–316. doi: 10.1080/14735903.2012.751701

Maxwell, S., &Frankenberger, T. (1992). Household food security: Concepts, indicators, measurements. Rome: International fund for agricultural development (IFAD) and UNICEF.

McCarthy N, Lipper L, Branca G., 2011. Climate-Smart Agriculture: Smallholder Adoption and Implications for Climate Change Adaptation and Mitigation. Mitigating Clim Chang Agric Ser 4:1–37.

McDowell, J.Z., Hess, J.J., 2012. Accessing adaptation: multiple stressors on livelihoods in the Bolivian highlands under a changing climate. Global Environ. Change 22, 342–352.

MEA. (2005). Ecosystem and human well-being: Our human planet. Summary for policy makers.

Meijerink, G. (2014). Farmers, traders and a commodity exchange: institutional change in Ethiopian sesame markets. Wageningen: Wageningen University.

Mengisteab, K., & Logan, I. (1995). Beyond economic liberalization in Africa: Structural adjustments and the alternatives. London: Zed Books.

Mersha, E., &Boken, V. (2005). Agricultural drought in Ethiopia. In: Boken KV, Cracknell AP, Heathcote LR (eds), Monitoring and predicting agricultural drought: a global study. Oxford University Press, p 227.

Mesfin, W. (1984). Rural vulnerability to famine in Ethiopia 1958–1977.

Mideksa TK (2010) Economic and distributional impacts of climate change: The case of Ethiopia. Glob Environ Chang 20:278–286. doi: 10.1016/j.gloenvcha.2009.11.007

Ministry of Trade, 2011 Annual report, Addis Ababa, Ethiopia

Mishra, A. and H. El-Osta. 2002. Risk management through enterprise diversification: A farm level analysis. Paper presented at AAEA meetings in Long Beach, CA, U.S.A. July 28-31.

MOA. 2011. Small-Scale Irrigation Capacity Building Strategy for Ethiopia, Natural Resource Sector, Addis Ababa, Ethiopia.

MoFED (Ministry of Finance and Economic Development).2002. Ethiopia: Sustainable Development and Poverty Reduction Program. Addis Ababa, Ethiopia.

MoFED. 2005. Ethiopia: Sustainable Development and Poverty Reduction Program (SDPRP). Addis Ababa, Ethiopia.

MoFED. 2006. A Plan for Accelerated and Sustained Development to End Poverty. Federal Democratic Republic of Ethiopia, Building on progress: Addis Ababa, Ethiopia.

MoFED. 2010. Growth and Transformation Plan (GTP) 2010/11-2014/15. Addis Ababa, Ethiopia.

Molua E. 2002. Climate Variability, Vulnerability and Effectiveness of Farm-Level Adaptation Options: The Challenges and Implications for Food Security in Southwestern Cameroon. Environment and Development Economics, 7: 529–545

Morton, J. F. (2007). The impact of climate change on smallholder and subsistence agriculture. Proceding of National Acadamicy of Sci.ence, 104(19680-19685.), 19680–5.

Moser, C., Norton, A., Conway, T., Ferguson, C., & Vizard, P. (2001). To claim our rights: livelihood security, human rights and sustainable development. London.

Mpogole, H. (2013). Round potatoes production in southern highlands of Tanzania: Market preferences, farmers varieties selection and profitability.

Muamba F. and Kraybill D. 2010. Weather Vulnerability, Climate Change, and Food Security in Mt. Kilimanjaro. Poster prepared for presentation at the Agricultural & Applied Economics Association 2010 AAEA, CAES, & WAEA Joint Annual Meeting. Denver, Colorado, July 25-27, 2010.

Müller C, Cramer W, Hare WL, Lotze-Campen H (2011) Climate change risks for African agriculture. Proc Natl Acad Sci 108:4313. doi: 10.1073/pnas.1015078108

NBE., 2014. National Bank of Ethiopia, The overall economic performance (July).

Negatu B, Kromhout H, Mekonnen Y, Vermeulen R (2016) Use of chemical pesticides in Ethiopia: a cross-sectional comparative study on knowledge, attitude and practice of farmers and farm workers in three farming systems. Ann OccupHyg 60(5):551–566.

Newman, C., M. Henchion, and A. Matthews (2003) A double-hurdle model of Irish household expenditure on prepared meals, Applied Economics, 35, 1053-1061.

Ng'ang'a, K., Van Wijk, T., & Rufino, C. (2016). Adaptation of agriculture to climate change in semi-arid Borena, Ethiopia. Regional Environmental Change, 16 (8), 2317-2330.

Ngigi SN., 2009 Climate change adaptation strategies: water resources management options for smallholder farming systems in sub-Saharan Africa. New York, NY: The Earth Institute at Columbia University.

Nhemachena, C., & Hassan, R. (2007). Micro-level analysis of farmers' adaptation to climate change in Southern Africa. IFPRI Discussion Paper, 714. IFPRI. Washington, DC.

Nkem, J., Perez, C., Santoso, H., &Idinoba, M. (2007). Methodological framework for vulnerability assessment of climate change impacts on forest-based development sectors.'' Second year annual report.

Niang, I., Ruppel, O., Abdrabo, M., Essel, A., Lennard, C., Padgham, J., & Urquhart, P. (2014). Africa. In V. Barros, C. Field, D. Dokken, M. Mastrandrea, K. Mach, T. Bilir, L.White, et al.,(Eds.), Climate change 2014: impacts, adaptation, and vulnerability. Part B: regional aspects. Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change, Cambridge University Press, Cambridge, pp. 1199–1265.

Nicholson, S.E., 2015. Long-term variability of the East African 'short rains' and its links to large-scale factors. Int. J. Climatol. 35, 3979–3990. http://dx.doi.org/10.1002/joc.4259.

NMA. (2001). Initial national communication of Ethiopia to the United Nations framework convention on climate change (UNFCCC). Addis Ababa, Ethiopia.

NMA. (2006). National adaptation programme of action of Ethiopia (NAPA). Addis Ababa, Ethiopia.

NMA. (2007). Climate change national adaptation programme of action of Ethiopia. The federal democratic republic of Ethiopia: Ministry of water resources. Addis Ababa: National Meteorological Agency (NMA).

NPC. (2016). Growth and transformation plan II (GTP II) (2015/16-2019/20) Volume I: Main text. Addis Ababa: Federal democratic republic of Ethiopia, National planning commission (NPC).

Nyangena, W. (2008). Social determinants of soil and water conservation in rural Kenya. Environment, Development and Sustainability, 10(6), 745–767.

Ofcansky, T.P., L. Berry 2004. Ethiopia A Country Study. Kessinger Publishing, LLC.

Orindi, V., Ochieng, A., Otiende, B., Bhadwal, S., Anantram, K., Nair, S., et al. (2006). Mapping climate vulnerability in poverty in Africa. In P. Thornton, P. Jones, T. Owiyo, R. Kruska, M. Herrero, P. Kristjanson, et al., Climate change and poverty in Africa. Report to the Department for Intern'l Development. Nairobi: ILRI.

Ortmun, G. F., & King, R. P. (2007). Agricultural cooperatives II: Can they facilitate access to small-scale farmers in South Africa to input and product market? Agrekon, 46(2), 219–244.

Pachauri, R. K. , Allen, M. R. , Barros, V. R. , Broome, J. , Cramer, W. , Christ, R. , Church, J. A. , Clarke, L. , Dahe, Q. , Dasgupta, P. , Dubash, N. K. , Edenhofer, O. , Elgizouli, I. , Field, C. B. , Forster, P. , Friedlingstein, P. , Fuglestvedt, J JP. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Vol. ISBN: 978-, / R. Pachauri and L. Meyer (editors) , Geneva, Switzerland. 2014.

Pankhurst, R. (1985). The History of famine and epidemics in Ethiopia: Prior to the twentieth century. Addis Ababa, Ethiopia: Relief and rehabilitation commission.

Parry M, Rosenzweig C, Livermore M (2005) Climate change, global food supply and risk of hunger. Philos Trans R Soc Lond B Biol Sci 360:2125–2138. doi: 10.1098/rstb.2005.1751

Parry M, Canziani OF, Palutikov JP, van der Linden PJ, & Hanson, C. (2007). Climate change 2007: impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge and New York.

Pender J., Nkonya E., Jagger P., Sserunkuumab D., Ssali H. 2004. Strategies to Increase Agricultural Productivity and Reduce Land Degradation: Evidence from Uganda. Agric Econ 31: 181-195.

Phillipo, F., Bushesha, M., &Mvena, Z. S. K. (2015). Adaptation strategies to climate variability and change and its limitations to smallholder farmers. A literature search. Journal of agriculture and rural development, 5(3),77–87.

Piya, L., Maharjan, K. L., Joshi, N. P., &Lall, K. (2013). Determinants of adaptation practices to climate change by Chepang households in the rural Mid-Hills of Nepal. Regional Environmental Change, 13(2), 437–447.

Porter, JR., Xie, L., Challinor, AJ., Cochrane, K., Howden, SM., Iqbal, MM., Lobell, DB., Travasso, MI. (2014). Food security and food production systems. In: Field, CB., Barros,VR., Dokken, DJ., Mach KJ, Mastrandrea MD, Bilir TE, Chatterjee M, Ebi KL, Estrada YO, Genova RC, Girma B, Kissel, ES., Levy, AN., MacCracken, S., Mastrandrea, PR., White, LL. (eds) Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, pp 485–533

Poudel, S., Basavaraja, H., Kunnal, L., Mahajanashetti, S. and Bhat, A. 2012. Crop diversification in Karnataka: An economic analysis. Department of Agricultural Economics, University of Agricultural Sciences, Dharwad, Karnataka.

Poulton, C., Al-Hassan, R., Cadish, G., Reddy, C. and Smith, L. 2001. The cash crop vs. food crop debate. Crop post harvest program. Issue Paper 3.

Rehima, M., Belay Kassa, Dawit Alemu. and Rashid S. 2013. Factors affecting farmers‟ crops diversification: evidence from SNNPR, Ethiopia. International Journal of Agricultural Sciences, 3(6): 558-565.

Reichardt, C., & Rallis, S. (1994). Qualitative and quantitative inquiries are not incompatible: A call for new partnership. In C. Rechardt& S. Rallis (Eds.), The qualitative-quantitative debate: New perspectives, San Francisco: Jossey-Bass, pp.85-92.

Reilly, J.M., Schimmelpfennig, D., 1999. Agricultural impact assessment, vulnerability, and the scope for adaptation. Clim. Change 43, 745–788.

Reutlinger, S. (1987). Food security and poverty in developing countries'. In J. et al Gittinger (Ed.), Food policy: Integrating supply, distribution and consumption, Baltimore. Johns Hopkins.

Review, S. (2016). Stern review final report on the economics of climate Change. Cambridge and New York.

Ribot, J. (2010). Vulnerability does not just fall from the Sky: Toward multi-scale pro-poor climate policy. In A. Mearns, Robin; Norton (Ed.), Social dimensions of climate change: Equity and vulnerability in a warming World, Washington DC: The World Bank, pp.47-74.

Robinson, S., Strzepek, K., Cervigni, R. (2013). The cost of adapting to climate change in Ethiopia: Sector wise and macro-economic estimates. Ethiopia Strategy Support Program II (ESSP) working Paper, 53.

Rosegrant, M. and Hazell, R.1999. Rural Asia transformed: the quiet revolution. International Food Policy Research Institute, Washington, D.C. USA.

Rosell, S. (2011). Regional perspective on rainfall change and variability in the central highlands of Ethiopia, 1978-2007. Applied Geography, 31, 329–338.

Rosenzweig, C., Elliott, J., Deryng, D., Ruane, A., Müller, C., Arneth, A., Jones, J. (2013). Assessing agricultural risks of climate change in the 21st century in a global gridded crop model intercomparison. Proceedings of the National Academy of Sciences, 111(9), 3268–3273.

Sanchez, Valeria (2005): "The Determinants of Rural Non-Farm Employment and Incomes in Bolivia", M.Sc thesis, Michigan State University

Schlenker, W., Lobell, DB. (2010). Robust negative impacts of climate change on African agriculture. Environmental Research Letters, 5, 014010.

Scoones, I. (1998). Sustainable rural livelihoods: a framework for analysis. IDS Working paper, 72, Institute of Development Studies.

Secker, J., Wimbush, E., Watson, J., & Milburn, K. (1995). Qualitative methods in health promotion research: Some criteria for quality. Health Education Journal, 54, 74–87.

Seleshi, Y., &Zanke, U. (2004). Recent changes in rainfall and rainy days in Ethiopia. International Journal of Climatology, 24, 973–983.

Seo, N., & Mendelsohn, R. (2008). Animal husbandry in Africa: climate change impacts and adaptations. African Journal of Agricultural and Resource Economics, 2(1), 65–82.

Shah, K., &Dulal, H. (2015). Household capacity to adapt to climate change and implications for food security in Trinidad and Tobago. Regional Journal for Environmental Change, 15 (7), 1379-1391.

Shiferaw T., Richard L., Christina H. 2005. Determinants of Food Security in Southern Ethiopia at the Household Level. Agricultural Economics 33: 351–363.

Sichoongwe, K. Laqrene, M. Ng'ng'ola, D. and Temb, G. 2014. The Determinants and Extent of Crop Diversification among Smallholder Farmers: A case study of Southern Province, Zambia, Malawi Strategy Support Program, Working Papers 05, Washington DC.

SID-Consult-Support Integrated Development, 2010. Market Assessment and Value Chain Analysis in BenishangulGumuz Regional State, Ethiopia Final Report.

Smit B, Burton I, Klein RJT, Street R (1999) The science of adaptation: a framework for assessment. Mitig Adapt Strateg Glob Chang 4:199–213

Smit, B., Burton, I., Klein, R., &Wandel, J. (2000). An anatomy of adaptation to climate change and variability. Climate Change, 45, 223–251.

Smit, B., &Pilifosova, O. (2001). Adaptation to climate change in the context of sustainable development and equity. In J. McCarthy, O. Canziani, N. Leary, & W. K. Dokken DJ (Eds.), Climate Change 2001: impacts, adaptation and vulnerability. IPCC working group II (pp. 877–912). Cambridge University Press.

Smit, B., Skinner, M.W., 2002. Adaptation options in agriculture to climate change: a typology. Mitig. Adapt. Strat. Glob. Change 7, 85–114.

Smith, J. (1983). Quantitative versus qualitative research: An attempt to clarify the issue. Educational Researcher, 12, 6–13.

Smith J, Lenhart SS (1996) Climate change adaptation policy options. Clim Res 6(2):193–201

Smith, J., Ragland, S., & Pitts, G. (1996). A process for evaluating anticipatory adaptation measures for climate change. Water, Air and Soil Pollution, 92(229-238).

SinafikehAsrat, Getawork Getachew and Alemayehu Seyoum. 2010. Trend and Determinants of Cereal Productivity: Econometrics Analysis of Nationally Representative Plot-level Data. International Food Policy Research Institute: Development Strategy and Governance Division Discussion Paper, June 2010, Addis Ababa, Ethiopia.

Stige, L. C., Stave, J., Chan, K., Ciannelli, L., Pattorelli, N., Glantz, M., Stenseth, N. (2006). The effect of climate variation on agro-pastoral production in Africa. Proceedings of the National Academy of Sciences, 103, 3049–3053.

Swinton, S. M. (2000). More social capital, less erosion: Evidence from Peruvian Altiplano. Tampa.

Solomon, S; Qin, D; Manning, M; Marquis, M; Averyt, K; Tignor, M M.B.; Miller, Jr HL. Climate change 2007: The physical science basis. Contribution of Working Group I to the fourth assessment report of the Intergovernmental Panel on Climate Change. Vol. 4, Environmental Research Letters.

Songok CK, Kipkorir EC, Mugalavai EM, Kwonyike AC, Ng'weno C. 2011 Improving the Participation of Agro-Pastoralists in Climate Change Adaptation and Disaster Risk Reduction Policy Formulation: A Case Study from Keiyo District, Kenya. In: Leal Filho W, editor. Experiences of Climate Change Adaptation in Africa. Springer Berlin Heidelberg. p. 55–68.

SorsaDebelaGelalcha 2009. Sesame trade arrangements, costs and risks in Ethiopia: A baseline survey. VC4PD Research Papers.

Stakhiv, E. (1993). Evaluation of IPCC adaptation strategies. USA.

Stern N. Stern review: the economics of climate change. vol. 30. London: HM Treasury; 2006.

Tafa, K., Beshah, T., Amsalu, A., Resource, N., Berehan, D., Berehan, D., … Dawa, D. (2009). Determinants of physical soil and water conservation practices in Ethiopia ' s Semi -Arid Tropics : The case of Bati district. Social and Basic Sciences Research Review, 2(12), 525–541.

Tashakkori, A., & Teddlie, C. (1998). Mixed methodology: Combining qualitative and quantitative approaches. Thousand Oaks & London.

Tazeze, A., Haji, J., &Ketema, M. (2012). Climate change strategies of smallholder farmers: the case of Babile district, East Harerghe Zone of Oromia Regional state of Ethiopia. Journal of Economics and Sustainable Development, 3, 1–12.

Tefera TL, Perret S, Kirsten JF. 2004 Diversity in Livelihoods and Farmers' Strategies in the Hararghe Highlands, Eastern Ethiopia. Int J Agric Sustain; 2(2):133–46.

Tesfahunegn, B., Mekonen, K., &Tekle, A. (2016). Farmers' perception on causes, indicators and determinants of climate change in northern Ethiopia: Implication for developing adaptation strategies. Applied Geography, 73(1), 1–12.

Teshager, M., Adgo, E., &Tilahun, T. (2014). Investigating the determinants of adaptation strategies to climate change: A case of Batti District, Amhara Regio. Intern'l Journal of Agricultural Research, 9(4), 169–186.

Tesso, G., Emana, B., &Ketema, M. (2012b). Econometric analysis of local level perception, adaptation and coping strategies to climate change induced shocks in North Shewa, Ethiopia. International Research Journal of Agricultural Science and Soil Science, 2(8), 347–363.

Thompson J, Scoones I. (2009). Addressing the dynamics of agri-food systems: an emerging agenda for social science research. Environ Sci Policy.12(4):386–97.

Thornton, P., Jones, P. G., Owiyo, T. M., Kruska, R. L., Herrero, M., Kristjanson, P., Kelkar, U. (2006). Mapping climate vulnerability and poverty in Africa: Report to the department for international development. Nirobi, Kenya.

Thornton, P.K., Jones, P.G., Owiyo, T., Kruska, R.L., Herrero, M., Orindi, V., Bhadwal, S., Kristjanson, P., Notenbaert, A., Bekele, N., Omolo, A., 2008. Climate change and poverty in Africa: mapping hotspots of vulnerability. Afr. J. Agric. Resour. Econ. 2 (1), 24–44.

Thornton, P., Jones PG, Alagarswamy G, Andresen J, H. M. (2010). Adapting to climate change: agricultural system and household impacts in East Africa. Agricultural Systems, 103(2), 73–82.

Thornton, P., Jones, P., Ericksen, P., &Challinor, A. (2011). Agriculture and food systems in sub-Saharan Africa in a 4 C? world. Philosophical Transactions of the Royal Society, 369, 117–136.

Thornton PK, Vermeulen S, Zougmore R, Kinyagi J, Kristjanson P (2012) Climate change, agriculture and food security (CCAFS): linking research and action in east and west Africa. CLIVAR exchange, 60:29-30

Thornton, P., & Herrero, M. (2014). Climate change adaptation in mixed crop-livestock systems in developing countries. Global Food Security, 3, 99–107.

Tilaye B (2010). 'How to involve smallholder farmers in commercial agriculture/horticulture'. Ethiopian horticulture producers and exporters association, Addis Ababa, Ethiopia.

Tirfe, Z., &Hamda, H. (2011). Farm households' food insecurity, determinants and coping strategies: The case of Fedis District, Easter Oromia, Ethiopia. Ethiopian Journal of Agricultural Economics, 8(1), 1–35.

Tittonell P, Giller KE (2013) When yield gaps are poverty traps: the paradigm of ecological intensification in African smallholder agriculture. Field Crop Res 143:76–90,

Tizale, C. (2007). The dynamics of soil degradation and incentives for optimal management in Central Highlands of Ethiopia. University of Pretoria, South Africa.

Tolosa, D. (2009). An assessment of the role of local institutions and social capital in household food security: A case study at two rural communities in Oromiya Zone, Amhara Region. In Proceeding of 16th International Conference of Ethiopian Studies, edited by Ege, S., Aspen, H., Teferra, B., and Bekele, S. Trondheim: Norwegian University of Science and Technology.

UN (United Nations) (2015) the millennum development goals report 2015. New York.

UNDP. (2008). Climate change and human development in Africa: assessing the risks and vulnerability of climate change in Kenya, Malawi and Ethiopia. Human development report 2007–08. New York.

UNDP (2015) African economic outlook: Ethiopia

UNFCCC. (1992). UNFCCC (United Nations Framework Convention on Climate Change), 1992. United Nations Framework Convention on Climate Change: Text. Geneva.

UN-ISDR. (2010). International strategy for disaster reduction (Africa). Country information Ethiopia.

USAID, 2017. Impact of climate change On select value chains in Mozambique. University of Arizona for the ATLAS Task Order, Washington, DC 20006

Von Braun, J., Rosegrant, M. W., Pandya-alorch, R., Cohen, M. J., Cline, S. A., Brown, M. A., & Bos, M. . (2005). New risks and opportunities for food security: scenario analysis for 2015 and 2050. Washington, D.C.

Wang, J., Mendelsohn, R., Dinar, A. and Huang, J. (2009). How do China's farmers adapt to climate change? Paper presented at the International Association of Agricultural Economics Conference, August 2009, Beijing.

Webb, P., Coates, J., Frongillo, E., Rogers, B. L., Swingdale, A., &Bilinsky, P. (2006). Measuring household food insecurity: Why it's so important and yet so difficult to do? Journal of Nutrition, 136(1), 1404–1408.

Webster, P.J., Moore, A.M., Loschigg, J.P., Leben, R.R., 1999. Coupled ocean-atmosphere dynamics in the Indian Ocean during 1997/98. Nature 401, 356–360.

Weiss, C. R. &Briglauer, W. (2000), "Determinants and Dynamics of Farm Diversification", Working paper EWP 0002. Department of Food Economics and Consumption Studies, University of Keil.

Wijnands, J. J. Biersteker and R. Hiel 2007. Oilseeds business opportunities in Ethiopia, Ministry of Agriculture, Nature and Food Quality, the Netherlands.

Williams, A.P., Funk, C., 2011. A westward extension of the warm pool leads to a westward extension of the Walker circulation, drying eastern Africa. Clim. Dynam. 37, 2417–2435.

Wisner, B., Blaikie, P., Cannon, T., & Davis, I. (2004). At risk: natural hazards, people's vulnerability and disasters. (2nd ed.). New York: Routledge.

Woldeab, T. (2003). Irrigation practices, state intervention and farmers Life-Worlds in drought-prone Tigray. Wageningen University, the Netherlands.

WondimagegnMesfin, BekabilFufa and Jema Haji. 2011. Pattern, trend and determinants of crop diversification: empirical evidence from smallholders in eastern Ethiopia. Journal of Economics and Sustainable Development, 2(8): 78-89.

Wood, SA., Jina, AS., Jain, M., Kristjanson, P., DeFries, RS. (2014). Smallholder farmer cropping decisions related to climate variability across multiple regions. Global Environmental Change, 25, 163–172.

Wooldridge, J.W. (2002); Econometric Analysis of Cross Section and Panel Data, Cambridge, Massachusetts: MIT Press.

World Bank. (1986). "Poverty and hunger: Issues and options for food security in developing countries." Washington D.C.

World Bank. (2006a). Ethiopia: Managing water resources to maximize sustainable growth. Country water resources assistance strategy. Washington, DC.

World Bank. (2006b). Ethiopia: Managing Water Resources to Maximize SustainableGrowth. A World Bank Water Resources Assistance Strategy for Ethiopia.

World Bank. (2009). Ethiopia: Climate risk factsheet summary report. Addis Ababa, Ethiopia.

World Bank, 2010. Economics of Adaptation to Climate Change : Ethiopia. Washington, DC.

World Bank, 2010. The Social Dimension of Adaptation to Climate Change in Ethiopia. Development and Climate Change Discussion Paper, Number 14. Wahington, D.C.: World Bank. Dev Clim Chang Discuss Pap.

World Bank, 2015d, '4th Economic Update: Overcoming Constraints in the Manufacturing Sector', World Bank, Washington, D.C.

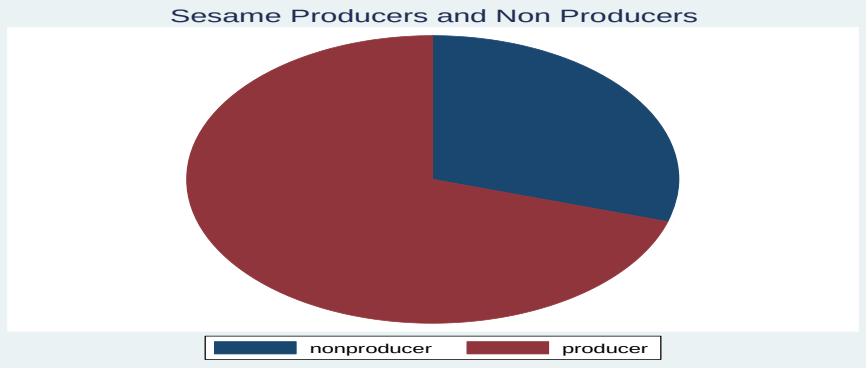
Yirga, C., & Hassan, R. . (2010). Social costs and incentives for optimal control of soil nutrient depletion in the central highlands of Ethiopia. Agricultural Systems, 103(3), 153–160.

Yu, B., and A. Nin-Pratt. 2014. Fertilizer adoption in Ethiopia's cereal production. Journal of Development and Agricultural Economics, 6(7): 318-337.

Zemedu, L., &Mesfin, W. (2014). Smallholders ' vulnerability to food insecurity and coping strategies in the face of climate change , East Hararghe , Ethiopia. Journal of Economics and Sustainable Development, 5(24), 86–101.

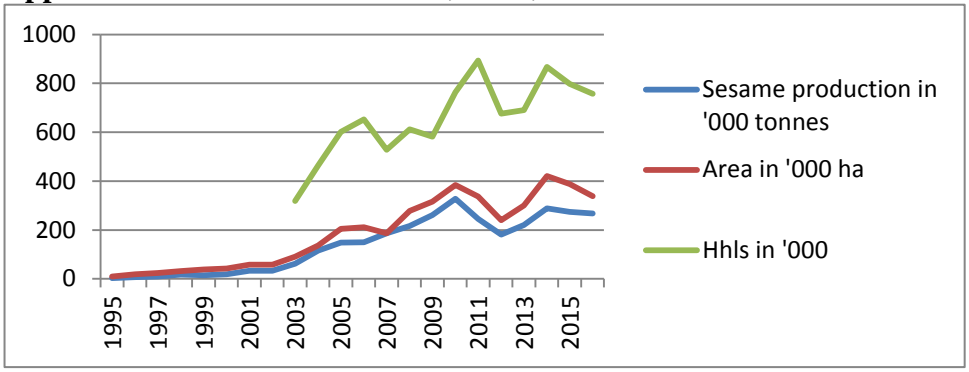
Appendences

Appendix I: Proportion of Sesame producers and non producers



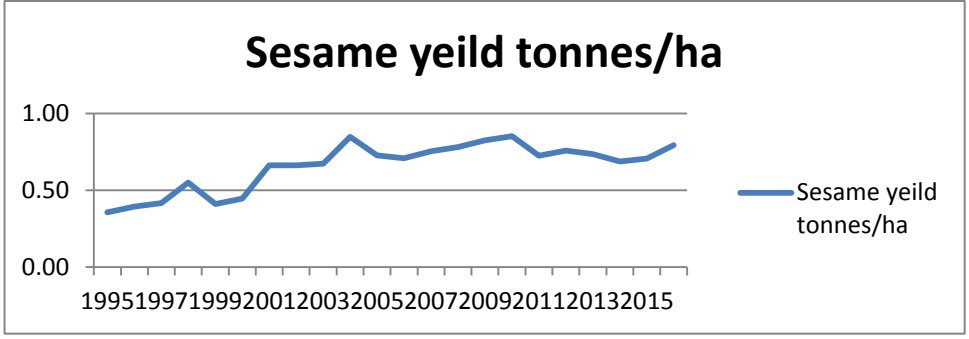
Source: survey data, April 2018

Appendix II: Sesame Production, Area, and households involved in Ethiopia (1995-2016)



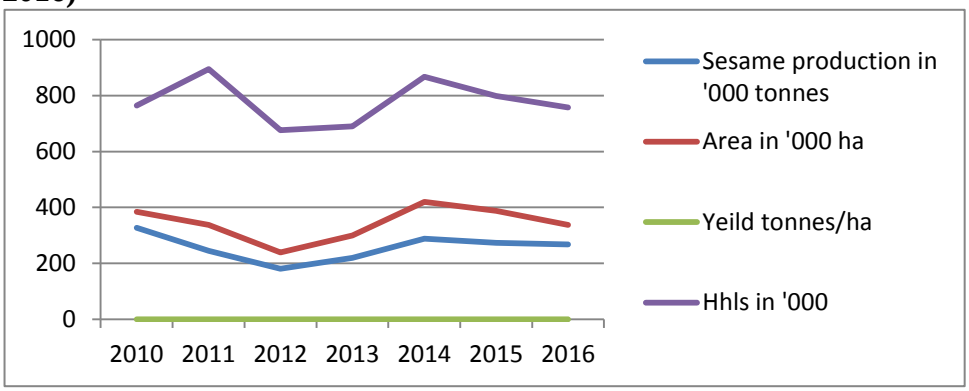
Source: based on CSA data (1995-2016)

Appendix III: Sesame yield in Ethiopia (1995-2016)



Source: based on CSA data (1995-2016)

Appendix IV: Sesame Production, Area, yield and households involved in Ethiopia (2010-2016)



Source: based on CSA data (2010-2016)

Appendix V: Conversion factor for computation of adult equivalent

	Adult Equivalent	
Age Group (Years)	Male	Female
<10	0.6	0.6
11-13	0.9	0.8
14-16	1	0.75
17-50	1	0.75
>50	1	0.7

Source: Storck et al. (1991)

Appendix VI: Conversion factors used to estimate tropical livestock unit (TLU) equivalents

Animal Category	TLU
Calf	0.25
Donkey (young)	0.35
Weaned Calf	0.34
Camel	1.25
Heifer	0.75
Sheep and goat (adult)	0.13
Cow and ox	1.00
Sheep and goat (young)	0.06
Horse	1.10
Chicken	0.013
Donkey (adult)	0.70

Source: Storck et al. (1991)

Appendix VII: VIF test result for the continuous explanatory variables

Variable	VIF		TOL
Land total	1.29	0.232	0.768
Education	1.21	0.192	0.808
Number of Oxen	1.20	0.166	0.834
Age	1.16	0.150	0.850
Distance from Extension	1.14	0.127	0.873
Income from Livestock	1.11	0.122	0.878
Distance from Market	1.09	0.087	0.913
Active family labor	1.07	0.076	0.924
Mean VIF	1.16		

Appendix VIII: Pairwise correlations for discrete variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) Sex	1.000					
(2) Credit	0.036*	1.000				
(3) Coop member	-0.108	0.059	1.000			
(4) Farm extension	-0.051*	0.062*	0.261*	1.000		
(5) Income nonfarm	0.059*	-0.003	-0.008	-0.034	1.000	
(6) Food availability	0.010	-0.254*	-0.453*	-0.243*	-0.032	1.000

* shows significance at the .5 level

Appendix IV: The Inter-Linkage: Sesame Production, Climate Change Adaptation and Food Security in Western Ethiopia

PhD Dissertation Research Household Survey Questionnaire, 2018

LOCATION

	Name	Code
1. Zone	_____	__
2. Woreda	_____	__
3. Kebele	_____	__

To be read by the enumerator:
"This survey is conducted by a PhD candidate from Addis Ababa University. The survey is to study Sesame production, climate change adaptation and farmers food security in order to make recommendations to policymakers as to how to improve the Sesame production and marketing. The information will not be reported as individual, and thus will be fully anonymous, without identity revealed."

HOUSEHOLD IDENTIFICATION

1. Name of the HH head _____
2. Household ID _____,__

Cell phone? _____ *Yes..1;* *No..2*

If yes, which number?_____

IDENTIFICATION SURVEY TEAM MEMBERS

code:_____

1. Enumerator's name: _____
2. Supervisor's Name: _____ code:_____
3. Date of the survey (EC): a. Day : __,__ b. Month : __,__

Supervisor's initials	Date (EC) (Day, Month)	O.K.	Returned to enumerator	Errors checked
	__,__ , __,__	__	__	__
	__,__ , __,__	__	__	__

Start time: __,__:__,__

SECTION A: HOUSEHOLD ROSTER

Please list all of the household members (USE DEFINITION PROVIDED WITH CODES). At the bottom of the page, include children under 19 years of age who are at school but do not reside in the house. Begin with the household head, then proceed with his/her spouse, children, grandchildren, etc. Include those who have temporarily migrated out and may not be present at the time of the interview. Record children away at school beginning with Id code 101:

Name of person	0. Respondent Yes …1 No …2	1. ID CODE	2. SEX Male….1 Female …2	3. What is [NAME'S] age? COMPLETED YEARS (RECORD "0" IF AGE<1) Years	4. What is [NAME'S] relationship to the head? Code (1)	5. What is [NAME'S] marital status (SKIP IF AGE<12) Code (2)	6. Is this person 5 years of age or older? Yes..1 → *Q.7* No…2 →*Next line*	7. What is [NAME'S] level of schooling? COMPLETED SCHOOLING Code (3)	8. Was [NAME] engaged in productive activities (working including any kind of household work) in 2009? Yes……1 → *Q.10* No…….2	9. Why has [NAME] not worked? Cannot find employment …1 Sick…… ……2 Handicapped…3 Too old……..4 Too young…….5 Student…… …..6 Other…… ……..7 →*Next line*	10. What was [NAME'S] primary occupation in 2009? Code (4)
Members who reside in the household											
		01	__		_1_	__	__	__,__	__	__	__,__
		02	__		__	__	__	__,__	__	__	__,__
		03	__		__	__	__	__,__	__	__	__,__
		04	__		__	__	__	__,__	__	__	__,__

		05	__		__	__	__	__,__	__	__	__,__
		06	__		__	__	__	__,__	__	__	__,__
		07	__		__	__	__	__,__	__	__	__,__
		08	__		__	__	__	__,__	__	__	__,__
		09	__		__	__	__	__,__	__	__	__,__
		10	__		__	__	__	__,__	__	__	__,__
		11	__		__	__	__	__,__	__	__	__,__
		12	__		__	__	__	__,__	__	__	__,__
		13	__		__	__	__	__,__	__	__	__,__
		14	__		__	__	__	__,__	__	__	__,__
		15	__		__	__	__	__,__	__	__	__,__
Students under age 19 who do not reside in the house for schooling purposes											
		101	__		__	__	__	__,__	__	__	__,__
		102	__		__	__	__	__,__	__	__	__,__
		103	__		__	__	__	__,__	__	__	__,__
		104	__		__	__	__	__,__	__	__	__,__

SECTION B1: LAND OWNERSHIP AND CULTIVATION

0. How many parcels did you own and/or cultivate crop agriculture **for which the harvest fell between**between**1 Tir 2009** and **30 Tahsas 2010 (Belg 2009 + Meher 2010)**?

CROP AGRICULTURE	Owned by the household								Rented in, sharecropped in or provided rent-free to the HH				
	Cultivated by the household *or* not cultivated				Cultivated by another household								
	1. Number	2. Local area	3. Local area unit code	4. Area (ha)	5. Number	6. Local area	7. Local area unit code	8. Area (ha)	9. Number	10. Local area	11. Local area unit code	12. Area (ha)	13. If rented in, price (Birr/ha)
TOTAL													

1. How many parcels did you own and/or use for grazing land between **1 Tir 2009** and **30 Tahsas 2010 (Belg 2009 + Meher 2010)**?

GRAZING LAND	Owned by the household								Rented in, sharecropped in or provided rent-free to the HH				
	Cultivated by the household *or* not cultivated				Cultivated by another household								
	4. Number	5. Local area	6. Local area unit code	7. Area (ha)	8. Number	9. Local area	10. Local area unit code	11. Area (ha)	12. Number	13. Local area	14. Local area unit code	15. Area (ha)	16. If rented in, price (Birr/ha)
TOTAL													

SECTION B2: CROP PRODUCTION (FOR ALL CULTIVATED PLOTS BY THE FARMER HIMSELF)

We would now like to ask you about each of the plots and how they were usedfor the <u>harvest that fell between</u>1 Tir 2009 and 30 Tahsas 2010 (Belg 2009 + Meher 2010)?

Please list for all the MAIN porducts that were harvested in belg 2009 or meher of 2010 how much was harvested.

NO	1.Crop *Code*	2.Season in 2009 Meher...……..1 Belg……. 2 Perennial……3	3.How much [crop] was harvested? In quintals	NO	1.Crop *Code*	2.Season in 2009 Meher...……..1 Belg…….2 Perennial……3	3.How much [crop] was harvested? In quintals
01				04			
02				05			
03				06			

SECTION B3: SESAME PRODUCTION

B30. Total land holding size_____ hectare? Total cultivated area _____ Hectare?

B31. For how many years did you cultivate sesame? Years

B32. Land size suitable for sesame production_____hectare

B33. Estimates land used for sesame cropping?_____hectare

B34. How much sesame has produced during the current farming seasons? Quintal

B35. How far is the farm from your home? _____minutes?

B36. For how many years did you cultivate sesame? Years

B37. Are you producing sesame continuously? 1. Yes 2. No

B38. Would you tell us the recent three years during which you produced sesame? _____, _____ and _____

B39. If your answer for B38 is no, what are the main reasons or main challenges in sesame cultivation? 1. decrease soil fertility 2. Price fall 3. lack of improved sesame seed 4. rain fall fluctuation [early/late] 5. heavy rain/snow 6. others specify……

B40. The land you used for sesame production is: 1 = fresh land ; 2 = land used for sorghum last year ; 3= land used for maize previous year ; 4= land used for Niger seed previous year
5=land used for other crop in previous year specify_____

B41. Which means of land preparation methods you used for sesame production:- 1= own oxen/donkey 2 = rented oxen/donkey 3 = traditional instruments 4= rented tractors

B42. If your answer for B31 is no, what are the main reasons? 1 = due to decrease in productivity 2= cannot grow sesame 3 = others specify……

B43. What types of oxen were used for sesame cropping? (Multiple answers possible) 1. Own 2. Shared 3. Leased 4. Other specify

B44. How many pairs of oxen were used for sesame cropping?

B45. What was the rental price of a pair of oxen in your Kebele? Birr

B46. How did you plant sesame? 1. Row planting 2. Broadcasting

B47. Dou you have production/marketing contracts for sesame products with any organization? 1.Yes 2. No

B48. If you have contract, for what? 1. Production 2. Marketing

C: LABOR Use

C01. Estimate the number and days of labor force used for sesame cropping for each activity? If the farmer doesn't produce sesame ask this question for other one main crop and specify the crop_____

No	Types of labor	The types of farm activity					
		Land preparation and planting		Weeding and cultivation		Harvesting	
		Number	days	Number	days	Number	days
1	Hired labor						
2	Family labor						
3	Exchange labor						

C02. What was the local daily wage rate for hire labor in your *Kebele*? Birr

C03. What is the average hour's labor spent on farming activities? _____hrs/day

C04 How many labor input used per hectare? _____Labor/Hectar?

D: TECHNOLOGY (Improved Seed and Fertilizer)

D01. Which types of sesame seed used during the current farming season? 1. Improved/hybrid variety 2. Local/traditional variety 3. both

D02. Which types of sesame seed do you prefer to plant?1. Improved/hybrid variety 2. Traditional/local variety 3. both

D03. Have you applied improved/hybrid sesame variety during the current farming season? 1.Yes 2. No

D04. Ifyes, to D03, have you sown improved/sesame variety in all of your sesame land? 1.Yes 2. No

D05. Ifyou did not use improved/hybrid sesame variety, what are your main reasons?

1. Lack of hybrid/ improved sesame variety
2. It's expensive (not profitable)
3. Transportation is expensive
4. Credit facility not available
5. Other, specify

D06. If you have adopted improved sesame seed please answer the following?

a. Is the yield of the improved seed superior to the local one 1. Yes 2. No
b. Is the improved seed mature early or let? 1. Early maturing 2. Not early maturing
c. How is the capacity of the improved seed in resisting disease? 1. Better 2. Not better
d. Is logging reduced? 1. Not 2. Yes
e. How is the color of the improved seed? 1. Better 2. Not better
f. Have you get training on sesame production? 1. Yes 2. No

D07. Please estimate the sesame seed utilization during the current farming season?

		Types of sesame seed used

No.		Improved variety	Local variety
1	How much kilogram of sesame seeds own?	kg	kg
2	Can you estimate the land covered by sesame seed?	ha	ha
3	Can you estimate the price of sesame seed purchased?	Birr	Birr

D08. Have you applied fertilizer for sesame production? 1. Yes 2. No

D09. Ifyes to D08, please estimate your fertilizer utilization during the current farming season?

No.		Types of Fertilizer	
		DAP	Urea
1	How much kilogram of fertilizer used for sesame cropping?	_____kg	_____kg
2	Estimate the sesame land covered with fertilizer?	_____ha	_____ha
3	How much money spent to purchase fertilizer for sesame field?	_____Birr	_____Birr

E: NON-FARM INCOME

E01. Do you have off/non-farm income source? 1. Yes 2.No

E02. If yes to E01, estimate the annual income form off/non-farm activities?

No.		1.Yes 2. No	How much is the income (Birr) per annum?
1	Daily labor		
2	Petty trade		
3	Handicraft		
4	Gift		
5	Remittance		
6	Salary		
7	Other, specify		

E03. If you have livestock, please fill the following Table?

Types of Animal	Number		Types of Animal	Number
Oxen			Donkey	
Caw			Sheep	
Heifer			Goat	
Calf			Chicken	
Mule			Beehives	
Horse			Other	

E04. What is you annual earning/ income from sale of livestock? _____Birr

F: INSTITUTIONAL FACTORS and MARKETING ASPECTS

F01. Do you have access to agricultural extension service? 1. Yes 2. No

F02. How far is the extension service center from you _____Km?

F03. Do you have access to farm to farm extension service? 1. Yes 2. No

F04. Did you obtain credit for sesame cropping? 1. Yes 2. No

F05. How far is the all weather road from your farm? Km?

F06. Are you a member of farmers' cooperative? 1. Yes 2. No

F07. Are you a member of two or more number of social groups in your areas? 1. Yes 2. No

F08. Quantity of sesame sold_____(in quintal)

F09. Price of Sesame per kilogram _____Birr

F10. How far is the nearest market center from your house? Km?

F11. Do you have access to market price information in any means? 1. Yes 2. No

F12. Where did you mostly sell your sesame produce?1. local buyers(collectors) 2. Cooperatives 3. tradersatprimarymarket4. others

F13. How did you sale your sesame produce? 1. Directly to the purchaser 2. Through brokers 3=others

F14. Time of sale: 1. immediately after harvest 2. after a month 3. after two months 4. let

F15.What are the main challenges in sesame marketing? 1. low price 2. lack of market information 3. price fluctuation 4. Other_____

G: CLIMATE

G01. Was there any sesame crop failure in any of these years? 1. Yes 2. No

G02. If yes, what are the sources of such failures and how many times this happened over the last two decades? 1. sesame disease 2. heavy rain/snow 3= long/short rain 4. other (specify_____) and _____numbers of time?

G03.Did the rainfall come on time? 1. Yes 2. too early 3. too late

G04. Was there enough rain on your fields at the beginning of the rainy seasons? 1. Yes 2. too little 3. too much

G05. Was there enough rain on your fields during the growing seasons? 1. Yes 2. too little 3. too much

G06. Did the rains stop on time on your fields? 1. Yes 2. too early 3. too late

G07. Did it rain during the harvest periods? 1.yes 2. No

G08. Over the last two decades, please specify the pattern of the change in temperature you have noticed.1=Increasing 2=Decreased 3. No change

G09. Do you think that the climate change and variability is true? Are you facing it? 1. Yes 2. No

G10. In response to climate change, have you taken any adaptation measures in order to reduce the impacts of climate change? 1. Yes 2. No

G11. If yes to question no.G10, please specify the three main climate change impact adaptation strategies you have taken in order of their importance? Type 1 for the major one, 2 for the next response and 3 for the last one

No.	Climate change adaptation	Responses
1	Agronomic practices (crop diversification, varying planting and harvesting dates, using drought tolerant and improved seeds)	
2	Reforestation (planting trees)	
3	Diversifying from farm to off/non–farm activities (pity trade, hand craft, daily laborer	
4	Water and soil conservation (stone bund, soil bund, check dum, terrace)	
5	Small-Scale Irrigation	
6	Temporary migration	
7	Others (specify if any)	

G12. If you diversify crop variety as a means of climate change adaptation, would you please list the main crop you adopt?

_____,_____,_____&_____

G13. Do you adopt sesame as diversification crop? 1. Yes 2. No

G14. If no to question G12, why? _____

G15. If your answer to question G10 is no, why?

No.	Reasons for not taking adaptation	Yes	No
1	Lack of information		

2	Lack of capital		
3	Lack of knowledge		
4	Shortage of farming land		
5	Not observing the climate related problems		
6	Giving less emphasis to climate change problems		
7	Others		

G16. What is the pattern of sesame production over the last 10 years? 1. increasing 2. decreasing

G17. If increasing what are the main reasons 1. enough rain 2. timely rain 3. high price 4.others_____

G18. If decreasing, why? 1. no enough rain 2. heavy rain 3. off-season rain 4. diseases 5. low price 6.others_____

G19. No of times drought occurred in the past 20 years? _____

Do you have access to climate information/early warning on food and drought? 1=Yes 2= No

G20. What are your main sources? 1. media 2. government/DA 3. NGO 4. other_____

H: FOOD SECURITY

H01. How many numbers of crops do you cultivate this year? _____

H02. Do you have stored crops from last time harvest? 1. Yes 2. No

H03.What is your main source of water supply? 1. Modern 2. Improved 3. Traditional

H04 What type of toilet facility do you use? 1. Modern 2. Improved 3. Traditional

H05 Number of income sources 1. Agriculture 2. Livestock 3. Daily labor 4. salary income 5. business income 6. remittances 7. Other

H06 Number of individuals in HH that engage in non-agricultural/ skilled income generating activities__

H07. Do you have food available for your family the whole year? 1. Yes 2. No

H08. This year have you faced periodic shortfall of food items? 1. No 2. Rarely 2. Sometimes 3. Often

H09. Is food price affordable to purchase from market? 1. Low 2. Medium 3. Expensive 4. Very expensive

H10. HFIAS questions:

1. In the past four weeks, did you worry that your household would not have enough food? 0.No 1. Rarely (1-2 times) 2. Sometimes (3-10 times) 3. often (more than 10 times)
2. In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources? 0. No 1. Rarely 2. Sometimes 3. often
3. In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources? 0. No 1. Rarely 2. Sometimes 3. often
4. In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food? 0. No 1. Rarely 2. Sometimes 3. often
5. In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food? 0.No 1.Rarely 2.Sometimes 3.Often
6. In the past four weeks, did you or any other household member have to eat fewer meals in a day because there was not enough food? 0.No 1.Rarely 2.Sometimes 3.Often
7. In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food? 0.No 1. Rarely 2.Sometimes 3.Often
8. In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food? 0.No 1.Rarely 2.Sometimes 3.Often
9. In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food? 0.No 1.Rarely 2.Sometimes 3.Often

H11. In order to overcome food shortage, have you employed any of the following strategies in relation to your farm and non-farm activities?

No.	Activities	Response		If no, please specify the reason why not?
		Yes	No	
1	Change crop variety			
2	Mixed farming			
3	Temporary migration			
4	Planting early maturing crop			
5	Soil and water management			
6	Planting trees			
7	Irrigation			
8	Drought resistant crop			
9	Seek off-farm employment			
10	Reduce number of livestock			
11	Others (specify if any			

SECTION I: FARMER CHARACTERISTICS

1. Is the household a member of the agricultural cooperative? Yes.1; No...2	___	
2. The household has been selected as a "model farmer" in the past 5 years in the community? Yes..1; No...2	___	

3. What is the religion of the head of household?	___	Code: Orthodox Christian…1; Protestant…2; Catholic…3; Muslim…4; None…5; Other…..6
4. What is the ethnicity of the head of household?	___	Code: Amhara…1; Oromo…2; Tigrayan…3; Other…13