ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

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EFFECT OF CLIMATE SMART AGRICULTURE PRACTICES ON INCOME AND FOOD SECURITY OF WHEAT AND TEFF GROWER FARMERS IN GIMBICHU WOREDA, OROMIA, ETHIOPIA

BY

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Effect of Climate Smart Agriculture Practices on Income and Food Security of Wheat and Teff Grower Farmers in Gimbichu Woreda, Oromia, Ethiopia

A Thesis Submitted to School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Requirement for the Degree of Masters of Arts in Rural and Livelihood development

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Declaration

This thesis is my original work and has not been presented for MA/MSc degree in any other university and that all the source and materials used for the thesis have been properly acknowledged.

Declared By: Kena Ghimbi

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Date:

Place: Addis Ababa University college of development studies, center for rural and livelihood development.

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Table Contents

List of Tables

List of Figures

Abbreviations

AGP	Agriculture Growth Program
ANOVA	Analysis of Variance
ATA	Agricultural Transformation Agency
CGIAR	Consultative Group on International Agricultural Research
CRGE	Climate Resilient Green Economy
CSA	Climate Smart Agriculture
EHNRI	Ethiopian Health and Nutrition Research Institute
EPRDF	Ethiopian people revolutionary democratic front
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GOE	Government of Ethiopia
GOOR	Government of Oromia Region
GTP	Growth and Transformation Plan
IPCC	Intergovernmental Panel on Climate Change
MOA	Ministry of Agriculture
NGO	Non-Governmental Organization
NMA	National Metrological Agency
PA	Peasant Association
SLM	Sustainable land management
SNNP	South Nation and Nationalities and People
SSA	Sub Saharan Africa
TLU	Tropical Livestock Units

Abstract

Crop production does play an important role in Ethiopia's economy by generating income as well as fulfilling the need of food. Gimbichu Woreda, is one of the potential area for crop production in Oromiya Regional state. Climate change impact has threatened this potential production area from time to time. Because of this, farmers are observed adopting different practices, i.e., climate smart agricultural (CSA) practices in the woredas of FAO, that help them to reduce the impacts and enhance the resilience of the farming system.. This study was aimed to assess the intensity of adoption, effect of adoption on food security and income of farming households and to identify the determinants of adoption intensity of CSA practices in Gimbichu woreda, East Shewa of Oromia National Regional State, Ethiopia. Multistage sampling techniques were employed to select study area (Gimbichu woreda) and household respondents. A total of 204 households were selected using purposive sampling method and household survey was also conducted with structured questionnaire. Multiple linear regression models was used to analyze the effect of CSA adoption intensity on income and food security and to identify the factor that affect adoption intensity on income and food security and to identify the factors that affect adoption intensity. It was found that reducing tillage, crop diversification practices which include (new crops and crop varieties, pest resistance, high yielding, drought tolerant and short season varieties) and crop rotation are the most widely adopted practices with 99.5%, 97.5% and 90.2% households practicing them, respectively. Whereas, tree based conservation agriculture was the least adopted practice with (15.7%) household practicing it. It could be concluded that high intensity level of climate smart crop production adopter households are likely better off in food security and income status. From targeted determining factors sex of household head, family labor size, farm land size, extension service, participation of social institutions, distance to market where buy agricultural input, accessing weather information, possessing irrigation and off-farm income are statistically significant at 0.05 level of significant in relation to adoption intensity of the practices. It could be concluded that high intensity level of climate smart crop production adopter households are likely better off in food security status. Finally, it could be recommended that every stakeholder in the sector (Agriculture) should better understand and take into account the factors that were identified in the study while implementing the climate smart crop production.

Key words:- CSA, Food security, Income, Adoption intensity

1. INTRODUCTION

1.1. Background of the study

Agriculture sector is vulnerable to climate change, and it is affected by changing production amount and land where crop can be produced. Climate change is very likely to affect food security at the global, regional and local level. Climate change can disrupt food availability, reduce access to food, and affect food quality (USDA, 2015). Increased variability in weather related shock and stress, resulting from climate change, increases the risk of production failure for farmers particularly those engaged in rain fed agriculture (IPCC, 2007).

The impact of climate change on crop production would be mainly through the change in temperature, rainfall, which collectively influences the length of growing period, time of critical growth rate, increased evapo-transpiration on and hence in some cases this seriously causes complete crop failure (Mahoo*et al.,* 2013).

Increment of climate element variability like rainfall inconsistency in the onset and cessation time, pests and disease affected household's crop production income negatively, this associated with the fact that increasing climate change can put crop production at risk. Therefore, rainfall variability and other climatic risk account for a significant share of agricultural production risk (World Bank, 2001; FAO, 2008).

In developing countries like Ethiopia where farming system is depend entirely on rain fed agriculture, they are vulnerable to extended drought, irregular rainfall pattern and extreme rain events which can significantly reduce yields and exacerbate food insecurity and poverty, for example from 2015/2016 El Nino drought 5.6 million people in Ethiopia require emergency food assistance in 2017 (OCHA, 2017).

Climate smart agriculture practices concept was originally put forth in 2010 by FAO after the Hague conference on agriculture, food security and climate change in 2009; has been presented as an alternative form of agriculture for conserving the environment while addressing the food needs of the world's population (FAO, 2014).

Climate smart agriculture practice incorporates different aims; it integrates the three dimensions of sustainable development such as economic, social and environmental and this helps jointly addressing food security and climate challenges (World Bank, 2010).Based on this definition, CSA has the following aims: increasing agricultural productivity and income; enhancing adaptation and building resilience to climate change and reducing or removing greenhouse gases (GHGs) where possible (FAO, 2014).

Different reports indicate that land and crop production and productivity increased due to an increase in land available for cultivation, increased availability of water for irrigation, improvement in the fertility status of the soil as well as improved agronomic practices. It is reported that soil organic matter content sequestration can be achieved by implementing sustainable land management practice that adds high amounts of biomass to the soil. This causes minimal soil disturbance, conserve soil and water, improve soil structure and enhance activity and species diversity of fauna (Woodfne, 2009). In addition to this all of factors that are sustainable weather condition can be challenged by climate change, and these may have great factor for crop production.

Weniga*et al.* (2019) tried to investigate the adoption practice of CSA in some area of Ghana based on World Bank climate village model. They found out that CSA practice was implemented by most of the farmers include using their personal experience to predict weather event, use of radio/television to access weather information, regulation/control of used in watering crops, minimum tillage, organic manuring and afforestation, likewise adopting of those practice are common in Ethiopia.

According to FAO (2016) efforts have been made to promote conservation agriculture and other CSA practices so far in Ethiopia. It has been confirmed that some encouraging results have been achieved at grassroots levels. There are Woredas where farmers have adopted some of the components of CSA practice including reduced tillage, soil mulching with crop residue and intercropping; other climate smart practices including agro-forestry and water harvesting.

Ethiopian agriculture is characterized nowadays by small-scale farmers, rain dependent production, using traditional technology, adopting low inputs and low output production systems. Due to different factors, Ethiopia is also categorized under countries that are more vulnerable to climate related hazards, which result in substantial negative impact on economic growth, particularly for agriculture and food security.

To mitigate the impact of climate change on crop, major stakeholder are promoting climate smart agriculture practice in Ethiopia in collaboration with Agricultural research institutions. CGIAR, numerous NGOs and the Ethiopian government have put in place a number of policies, strategies and laws, and these are designed to support climate change mitigation and adaptation and sustainable development (FAO, 2016).

With the support of those major stakeholders and polices, agricultural development activities are sustained by addressing climate change impacts. The main activities of climate smart agriculture practice package includes practices like integrated watershed management, integrated soil fertility management, conservation agriculture and crop residue management (FAO, 2016).

As mentioned earlier, climate smart agriculture practice introduces opportunity to address climate change challenges, and it simultaneously supporting economic growth and ensure food security mainly through increasing productivity at the same time improving agricultural production and income of the farmers'.

This study is aimed to identify the status of adoption, analyze determining factors and challenges in adopting climate smart cattle production practice and forward problem oriented context specific strategic action to enhance adoption and scaling up practice by smallholder farmers in Gimbicu woreda, East Shewa Zone, Oromia National Regional State, Ethiopia.

1.2. Statement of problem

Climate change has direct effect on the crop production through increased temperature, change in rainfall amount and patterns of distribution. For example higher CO_2 levels can affect crop yields, these reduce the quality of production nutrient by reducing protein, nitrogen and minerals content in most plant species like wheat, soybeans. This reveals that the rise of CO_2 will threaten human food system directly.

The 4th assessment report of IPCC report predicts that climate change could cause yields to decrease by as much as 50% in some highly vulnerable areas including sub- Saharan Africa. Besides, cereal production growth for a range of crops in SSA is projected to decline by a net 3.2 percent in 2050 due to climate change.

This showed as there will expected future area loss; for instance (Yumiya *et al.,* 2011) mentioned the production failure of teff production in Ethiopia and the pattern of teff species will be restricted to higher altitude due to future change in climate.

In Ethiopia, majority of farmers income and food existence rely on the crop production they need stable income and consumption from their farming activities for continuing livelihood. If they able to get enough income from crop production, there is chance to access food commodities that they are not producing by themselves. This implies that many other sector impact of climate change on crop production prolong to food security and income.

CSA as an approach helps to transform and re-orient the farming system at household and landscape levels to support food security and increase income under the new realities of climate change (FAO, 2013). In spite of the development of several CSA technologies and practices and the gains arising from it, wide-scale adoption of CSA practice remains a challenge especially amongst smallholder farmers in Africa in general and in Ethiopia in particular (Barnard, 2015).

Adaptation rate of CSA is still poor in Ethiopia according to the study conducted at national level. It showed that the main challenges are open grazing, frequent land ploughing and removal. Burning of crop residues, land degradation, weak capacity, weak coordination and loss of forests are also the identified challenges (FAO, 2016).

There is a lack of adequate research findings on CSA practices in Ethiopia for the various agro-ecological zones, soil types, rainfall patterns, farming systems, as well as temperature and moisture ranges. Hence, there is a need to support more research projects on CSA particularly actions research and filed based research (FAO, 2017).

For instance, those pertinent literatures addressed the impact of climate smart agriculture practices on food security and on income are also the determinants of farmers' choice to adaptation of CSA (Lipper *et al.,* 2014; Temesgen *et al.,* 2008; Tamiru Lemi and Fekadu Hailu, 2019; CGIAR 2013). Hence, such studies consider the sum of climate smart agriculture practice adaption impact on the general agriculture production in combat of climate change effect, but nowadays, climate change impact severely tested the food security and income of farmers. Therefore, within such findings it is difficult to disaggregate the impact on food security and income

Consequently, assessment of effect of climate smart agriculture practices on income and food security with specifically focus on the role of demographic, socioeconomic aspects, the likely change in the magnitude of CSA practices adoption intensity effect on the food security and income of the farmers. When the CSA practices adoption intensity change marginally and projected, there were change on income and food security with resisting future climate changes impacts are among the gaps which the study intends to bridge.

Though, an effort aimed at identifies determinant factors in adopting CSA for crop production of farmers, such assessment would have been enabled adoption of cause feasible adaptation action to minimize the vulnerability of crop production and the farmers' those their livelihood directly depend.

1.3. Objectives of the Research

1.3.1. General Objective

The general objective of the study to assess ,the status of adoption intensity of CSA practices and their effect on income and food security of wheat and teff producer smallholder households in Gimbichu Woreda.

1.3.2. Specific Objectives

The specific objectives of the research are to:

- Examine the practices of CSA in the study area.
- Investigate the effect of adoption intensity of CSA practices on food security and income among small holder wheat and teff producer farmers.
- Identifying the factors that affect the adoption intensity of CSA practices

1.3.3. Research questions

The following questions are addressed in this research

- What type of the CSA practices are highly adopted by smallholder producers of Teff and wheat in the study area?
- What are the determinants of adoption intensity of climate smart agriculture practices among Teff and wheat production?
- What is the relationship between adoption intensity of CSA practices on crop production with food security and income of smallholder householders in the study area?

1.4. Significance of the study

The result of this study is expected to benefit farmers, local government and development participant in particular. This benefits them by improving their knowledge and awareness about overall status of climate smart agriculture practice within the selected Woreda. In addition, the findings and insights of this research might help future researchers, who want to pursue further investigation in the area in other Woredas. This study might also be helping to evaluate and to show the contributions of climate smart agriculture practice on income, productivity and food security of smallholder households.

1.5. Scope and limitation of the study

The study has limited its scope within three rural kebeles of Gimibichu woreda. The area was selected purposely; the study considers only smallholder farmers that are Teff and Wheat producers from each agro-climatic zones. In fact, climate smart agriculture practice contain both crop and livestock production, but this study focuses only on contribution of practice on crop type teff and wheat to enhance food security, increase income and productivity. The main reason of limiting the study area into the three rural kebeles of Gimibichu woreda is due to resources (time and financial) limitation.

1.6. Organization of the Study

This study document organizes into five chapters; the first chapters discuss about the background of study, objective, statement of the problem and limitation of the study. Chapter two elaborates and covers the relevant literature reviews focusing on the empirical studies and context of Ethiopia. Chapter three covers the research methodology that includes a descriptive of the study districts, research design, sampling unit, and sample size, sampling technique, sources of data, collection methods and data analyses methods. Both descriptive and econometric results are presented and discussed under chapter four. At the end, based on the finding, recommendation and policy implication are discussed under chapter five.

2. LITERATURE REVIEW

2.1. Climate Smart Agriculture

CSA practices is an approach for addressing the development efforts toward the technical, policy and investment condition related issues to achieve sustainable agricultural development for food security under climate change along with eradication of poverty. But, its focus is to act at local where there is already impact of climate change (CSA source book, 2013).

As Demissie (2018) described, there are three paradigms that are used to explain the determinants adoption option of farmers when adopting a new climate smart agricultural technology. These are innovation-diffusion model, adoption perception model and the economic constraints model. Innovation-diffusion model contents that access to information about an innovation influences (climate smart agricultural technology) adoption. Lack of information can increase the risk of planting expensive seeds that may not survive or otherwise do poorly (Ajayi OC, *et al.,* 2007). Institutional factors that determine farmer's decision to adopt climate smart agriculture practices includes availability of credit and infrastructure, access of agricultural extension agents, access of information on climate change and participation of farmers in social and labor organization of the community (Malefiya, 2017 cited in Demissie, 2018, 2017 cited in Demissie, 2018).

According to 2010 World Bank development and climate change report, believing climate smart agriculture practice is means of achieving sustainable development goals, but for farmers to be climate smart, they need to be engaged in six components include in model outlined to develop and measure CSA practice: carbon, water, nitrogen, energy, weather and knowledge smart practices (World Bank, 2010).

Carbon smart practice contains practice like afforestation, minimum tillage, organic manuring and composting, the advantage of this enabling soil potential to store carbon and increase soil organic matter (Zhang's *et al.,* 2017)

Water smart practice present opportunities for farmers to mitigate climate induced water stress innovative technologies and pro-water conservation behaviors create water efficiency and enable access to water during water scarcity period (Quiroga *et al.,* 2015). Rainwater harvesting, mulching, on-farm water management, terracing and contouring can save costs and provide high quality water for production all year round; consequently, increasing yields and income of farmers (Botha *et al.,* 2015; karpouzoglou & barron, 2014, Mul *et al.*, 2011, as cited in Samuel, 2019).Weather occurrences including floods, storm surges and prolonged drought can be devastating to crop productivity.

Farmer can minimize climate change impacts by adopting weather smart practices; use of mobile phones or internet access of weather information, index based insurance (IBI), usage of radio/television for weather information (Shannon & motha, 2015; Conradt *et al.*, 2015; Hochrainer*et al.*, 2014). IBI for instance, is an innovative approach to insurance provision that pays out benefits or compensate client on the basis of predetermined index (example, rainfall level or temperature variation) for loss of assets and investments, resulting from weather and catastrophic events (Conradt *et al.*, 2015). Mobile phones and internet enable farmers to receive information from colleague's meteorological stations and other interests groups on weather events through voice messages or direct access. They help to increase farmer's preparedness for climate change events and enable them to act accordingly (Aker & Ksoll, 2015).

Knowledge and awareness of sustainable agriculture practices and climate events are essential in climate change adaptation and mitigation (Keshavarz & Karami, 2014). Farmer to farmer knowledge sharing and information of farmer based associations help to improve the management of yields and act as a conduit to bring farmers knowledge to researchers (Bournaris *et al.*, 2016;Keshavarz & Karami, 2014).

Knowledge on market prices of farm produce enables farmers to decide on the type of inputs to buy and when to sell farm produce. These results in cutting down investment cost, hence, profit maximization for expansion of farms (Ogutu *et al.*, 2014).

Ethiopia also one of natural disasters affected country in Africa; this climate change caused disaster destroying habitats and disturbing human being life. Some of natural resource disaster cause that country's experienced are drought, lack of sufficient rainfall and etc.. Thus, problem there frequency and intensity become increased from time to time. Such impacts create severe famine or heavy floods, loose of life, loss of agriculture crops and animals. Due to this impact in productivity of various crops, this condition create a challenge to food security, increased risk of diseases outbreak, pushing farmers in rural area back below poverty line.

To employee climate smart agriculture practice, GOE prepared the guideline based on the assessment by listing the aim of intervention. Some of the proposed interventions in the agriculture sector (to soil-based emissions from agriculture and limit the pressure on forests from the expansion of land under cultivation) according to the strategy documents:

- Intensify agriculture through usage of improved inputs and better residue management resulting in a decreased requirement for additional agricultural land that would primarily be taken from forests;
- Create new agricultural land in degraded areas through small, medium, and large-scale irrigation to reduce the pressure on forests if expansion of the cultivated area becomes necessary;
- Introduce lower-emission agricultural techniques, ranging from the use of carbon- and nitrogen-efficient crop cultivars to the promotion of organic fertilizers. These measures would reduce emissions from already cultivated areas.

Sometimes, climate change considers as only increment of temperature, but National council for climate change 2014 said that climate change have to be understood in three ways. The first is the actual increase frequency of natural disasters; the second is the concurrent impact due to change in weather as low or heavy or no rain or impacts increased temperature are on productivity of crops, animal or fish catch. And the third one is unforeseen changes in weather during seasons. So, we can conclude that this climate change has multiple dimensional impacts.

As stated on the introduction section, climate smart agriculture has high role to ensure food security by addressing impact of climate change which visible at current and projected through two actions which are adaptation and mitigation.

Based on the definition of impacts by National council for climate change 2014, the effect of climate change on natural and anthropogenic systems; when integrate this definition to climate smart agriculture, impact will be felt on different area: landscapes, ecosystems, watersheds, infrastructure, farms, agricultural production and markets.

2.2. Climate Smart Agricultural production

Climate smart agriculture practices contain both proven practical techniques and innovative technique. FAO,2016 puts those practices as follows: mulching, intercropping, conservation agriculture, crop rotation, integrated crop – livestock management, agro-forestry, improved grazing and improved water management as proven practical and improved weather forecasting early – warning systems and climate risk insurance as innovative practices.

To achieve the ever growing demand of food security, to reduce poverty and to achieve agricultural development goals through enhancing the productivity and income from agriculture, adapting and building resilience to climate change and reduction of emission intensity per unit of product compared to past trend is an urgent call for the sector (FAO, 2013). Climate smart agriculture (CSA) is an approach to address this climate variability problem in effective way. CSA aim to improve food security help communities adapt to climate change and contribute to climate change mitigation by adopting appropriate practices, developing enabling policies, institutions and mobilizing needed finances (Lipper *et al.*, 2014).

When we come to Ethiopian context, the major effect of climate change on crop production can be described in different scenarios. Crop production in the country is highly correlated to the rainfall patterns. Rainfall variability and recurrent drought are leading to frequent crop failures, loss of life and property (CGIAR, 2013). However, farmers use different management practices that include selecting the most favorable crops, cultivars, rotations, adjusting frequency of tillage, inter row cultivation techniques, traditional irrigation and water harvesting practices.

Various CSA practice implemented by farmers by support of government and stakeholders, the common practices are like integrated soil fertility management, integrated watershed management, sustainable land management conservation agriculture, crop residue management, agro-forestry, composting, rangeland management and promotion of improved livestock feed.

Government of Ethiopia underway different program to aware farmers on soil fertility management through extension worker; the main activities being promoted include training and promotion of appropriate fertilizer application, composting, crop rotation and intercropping with a focus on improving food security. This all practices help to improve the chemical, physical and biological characteristics of soils, According to FAO (2016), the advantage of using organic manure includes the addition of nutrients to the soil and the sequestration of carbon dioxide, thereby reducing its adverse effects on global warming. Traditionally, in Ethiopia, soil conservation practice undertaken before long time like reduced tillage, but as FAO (2016) stated, the promotion of conservation agriculture technology began in earnest in 1998 through the joint promotion and demonstration of the technology on the plots of 77 farmer by sasakawa global (SG 2000), makobu and regional agricultural development bureaus.

During 1998 – 2003 trials of conservation, agriculture practices were carried out at different research center on major crop maize, teff and sorghum. These trials indicated that conservation tillage plots gave higher yields compared with the conventional tillage (Tesfa, 2001; Worku, 2001, Tolesa, 2001, as cited in FAO, 2016); additionally, lower production cost for conservation agriculture field.

Based on this, in 2010 in Ethiopia, 24 conservation agriculture demonstration plots established and 600 smallholder farmers involved from three different regions(Wondwossen *et al.,* 2008) reported that adopter of three components of conservation agriculture (mulching, minimum ploughing and crop rotation) have higher yields than non- adopters.

Agro-forestry: this practice was done by planting or reforestation of trees and shrubs into farmland. Basically, Ethiopian farmers have experience and culture of planting and conserving different types of trees and shrubs. This is true in Ethiopia, for moringa tree is traditionally inter-planted with sorghum and crops in Konso, Omo ,Burji, Sena and Mele Woreda of SNNP regional state.

According to the agro-forestry, researcher trusts this practice has a lot of benefits. Some of these are they can maintain more favorable soil physical properties than agriculture through organic matter maintenance and the effect of tree roots can control runoff and soil erosion. Thereby reducing losses of water, soil material, organic matter and nutrients, nitrogen-fixing trees and shrubs can substantially increase nitrogen inputs to agro forestry system. Generally, agro-forestry can provide more diverse farm economy and stimulate the whole rural economy, leading to more stable farms and communities

Crop rotation and intercropping: the aim of this practice is also the perspective of keeping soil fertility. In Ethiopia, the importance of crop rotation in improving soil structure, reducing soil degradation and improving yield is known. Increased levels of soil organic matter enhance water and nutrient retention and decrease synthetic fertilizer requirements. This practice was also promoted in Ethiopia recently with related to climate change. This practice also has contribution, for it allows better nutrient management through crop rotation can decrease the use of nitrogen fertilizer and related greenhouse gas (GHG) emissions associated with the production, transportation and use chemical fertilizers (PANW, 2012).

Table1: Summary of some common CSA practices in Ethiopia (source FAO, 2016)

CSA practice	Components	Why it is climate smart
Conservation agriculture	• Reduce tillage • Crop residue management, mulching, intercropping • Crop rotation/intercropping with cereals and legumes	• Carbon sequestration • Reduce existing emissions • Resilience to dry and hot spells
Integrated soil fertility management	• Compost and manure management, including green manuring • Efficient fertilizer application techniques (time, method, amount)	• Reduced emission of nitrous oxide and CH_4 • Improved soil productivity
Small-scale irrigation	• Year round cropping • Efficient water utilization	• Creating carbon sink • Improved yields • Improved food security
Agroforestry	• Tree based conservation agriculture • Practiced both traditionally and as improved practice • Farmer-managed natural regeneration	• Trees store large quantities of CO_2 • Can support resilience and improved productivity of agriculture
Crop diversification	• Popularization of new crops and crop varieties • Pest resistance, high yielding, tolerant to drought, short season	• Ensure food security • Resilience to weather variability • Alternative livelihoods and improved incomes
Other	• In situ water conservation/harvesting • Early warning systems and improved weather information • Support to alternative energy-fuel efficient stove, biofuels • Crop and livestock insurance • Livelihood diversification (apiculture, aquaculture) • Post-harvest technologies (agro processing, storage)	• Resilience of agriculture • Improved incomes • Reduced emissions • Reduced deforestation • Reduced climate risk

2.3. Policies, Strategies and Institutions

Sub Saharan countries climate variability and change challenge the countries efforts to ensure development and economic development. Ethiopia is among the countries that are most vulnerable to climate change in East Africa. This process is expected to negatively affect the progress of the sector including agriculture, transportation, energy and health (CARIAA working paper 2016). Ethiopia has signed and/or ratified many of the international conventions and protocols to climate change and land degradation (FAO, 2016); including United Nations framework convention on climate change (1994); the convention on Biological Diversity (CBD) and the United Nations Convention to Combat Desertification (UNCCD).

Policies, laws and strategies that are relevant to climate change in Ethiopia include the Climate Resilient Green Economy Strategy (2011), National adaptation Program of Action (NAPA), Ethiopian Programmed of Adaptation to Climate Change (EPACC) of 2011, Nationally Appropriate Mitigation Actions (NAMA) of 2010, Rural Development Policy and Strategies (2003), Growth and transformation Plan (GTP), CAADP compact and the National Environment Policy of Ethiopia (1997).

The GTP II (2015/16 – 2019/20) has been formulated to carry forward the basis, objectives and strategic directions of GTP I. In the GTP II, the issue of climate change is recognized; the main basis of GTPII is the country's vision to become a lower middle-income country by 2025. The realization of this vision calls for creating competitive, productive and inclusive economy in all aspects.

In GTP II period, agriculture will remain the main driver of the rapid and inclusive economic growth and development. It is also expected to be the main source of growth doe the modern productive sectors (GTP document). Therefore, besides promoting the productivity and quality of staple food crops production, special attention will also be given to high value crops, industrial inputs and export commodities.

As described in the document studies indicate that by 2050, the temperature of the country could increase in the range of 1.7 to 2.1 degree Celsius unless appropriate mitigation measures are taken (GTP document). The document mentioned that GTP II major emphasis is given to building a climate resilient green economy in the context of sustainable development and realizing the vision of becoming a lower middle-income country by 2025. To achieve this objective, countries formulated and implemented climate resilient green economy strategy. The main area of implementation will be made area of improving crop and livestock productivity to ensure food security through reducing emissions, protecting forests and re-afforestation including carbon stocks.

In addition to the GTP plan, CRGE strategy was released in 2011 and in 2012; the strategy published, the CRGE coordination unit is established within the MoA Natural resources management directorate. The major responsibility of the CRGE coordination unit is mainstreaming climate change adaptation and mitigation strategies into the regular activities of each sector in 27 Woredas of the four main regions (FAO, 2016).

CRGE strategy aim, to achieve carbon neutral middle income status before 2025 based on four pillars of which the first two pillars are mainly related to CSA (FAO 2010) including improving crop and livestock production practice for greater food security and better income for farmers while reducing emissions and protecting and re –establishing forests for their economic and ecological value, including carbon stocks.

Institutional arrangements for coordinating and implementing public policy responses for CRGE are being developed. The responsibility of coordinating CRGE planning lies with the ministry of environment and forests. The CRGE inter – ministerial committee, under the council of ministers, provides oversight of the CRGE process. This committee is the top body of within CRGE institutional arrangements. It is responsible for providing overall directions to the CRGE process and for approving financial decisions of the CRGE facility. The committee comprises state ministers and senior officials from participating institutions.

Table 2: Summary of the key policies relevant to CSA in Ethiopia
Source FAO 2010

Policy	**Year**	**Intention or goal**
Environmental policy of Ethiopia	1997	Overall guidance in the conservation and sustainable utilization of the country environmental resources
Environmental impact Assessment	Proclamation 2002	Ensure that the environmental implication are taken into account before decisions are made
National Adaptation Program of Action (NAPA)	2007	The NAPA represented the first step in coordinating adaptation activities across government sectors
CAADP compact	2009	One of the pillars of CAADP is extending the area under sustainable land management and reliable water control; systems.
Growth and transformation plan (GTP)	2010	The GTP recognize that the environment is a vital pillar of sustainable development
Ethiopian Programme of Adaptation to climate change (EPACC)	2011	The agriculture sector climate change adaptation plan
Ethiopian Programmed of Adaptation to climate change (EPACC)	2011	More programmatic approach to adaptation planning
Climate Resilient Green Economy Strategy	2011	Carbon-neutral middle income status before 2025

2.4. Food security and Climate Change

According to FAO estimation, at 2050 world population will increase by one third and food required for food security by 60%. So, we can understand from this estimation that increment of world population has been accompanied with increased demand for food consumption. Once again, FAO state of food insecurity for 2010 assesses that nearly 1 billion people are estimated to be undernourished, representing almost 16 per cent of the population of developing countries (Napoli, 2010/11).

The definition that has acquired the broadest acceptance is that of the world food summit (WFS) in November 1996; "when all people can be access sufficient safe and nutrition food at all-time having physically, socially and economically and if this food meets their dietary needs and food preferences for an active healthy life it called food security is exists"

Like food security definition, food insecurity has also broad definition. Scholars give different definitions from different point of view; It should be stressed that the difference between food security, famine and hunger should be clearly demarcated: food security related most of the time with availability of food, which is differ from food insecurity which define as famine and hunger are the consequence of the non-availability of food(Napoli 2010/2011). FAO defines food insecurity as "a situation that exists when people lack secure access to sufficient amounts of safe and nutritious food for normal growth and development and an active and healthy life. (Napoli, 2011, p19)"

Climate change is a threat to food security systems and one of the biggest challenges in the twenty –first century (FAO, 2013). Report of (FAO, 2011) showed that agricultural system should be transformed to increase the productivity capacity and stability in the wake of climate change. Climate change in Ethiopia is a serious threat for agricultural production which is the main source of local food production. The main effect of climate change on crop production will be changes in regular crop planting times, length of growing season and shifts in suitable crop types or cultivars (Mahoo *et al.,* 2013).

Ethiopian agriculture production is rain feed system, hence, variability in rainfall pattern and drought have disrupted crop production and exacerbated food insecurity in many part of the countries. The trend in number of food insecure people due to climate related calamities is increasing, and reached at a peak of 13 million 2002/2003 (Mahoo *et al.,* 2013). Climate risk fact sheet of 2011 of World Bank showed that between 1999 and 2004, more than half of all households in Ethiopia experienced at least one major drought shock.

Page 19

Table 3: Effect of drought and rainfall variability on famine in Ethiopia
Source Oxfam Ethiopia (2011), Cited on CGIR (2013)

Drought	**Regional affected**	**Impact on human life property**
1964 - 1966	Tigray and wollo	About 1.5 million people affected
1973 - 1974	Tigray and Wollo	0.2 million people and 30% of livestock dead
1978 – 1979	Southern Ethiopia	1.4 million
1982	Northern Ethiopia	2 million people affected
1983 – 1984	Ethiopia	8 million people affected
1987 – 1988	Ethiopia	7 million people affected
1990 – 1992	North, Eastern, Southeastern Ethiopia	About 0.5 million people affected
1993 – 1994	Tigray and Wollo	7.6 million people affected
2000 – 2001	Ethiopia	About 10.5 million people affected
2002 – 2003	Ethiopia	13 million people in need of food assistance
2005 - 2006	Somali Region	1.75 million people need food assistance
2007 – 2008	Arsi, West Arsi and West shewa	3.4 million people need emer. food relief
2009 -2010	Eastern and Southern Tigray, Eastern Amhara, Eastern Oromia, Somali, SNNP, Gambela	5.2 million people required emergency food assistance

2.5. Agricultural income and Climate Change

Agricultural income refers to income earned or revenue derived from source that includes farming land, building on or identified with an agricultural land and commercial produce from a horticultural land. Most of the world's live in rural area, rural poverty is acute in sub-Saharan Africa and south Asia. Landless, subsistence farmers, or herders struggle to fulfill their basic needs. According to FAO (2015) report, in most of the countries where the organization made evaluation, poverty among small farmers is wide spreading. And in most countries much higher than the national poverty headcount rate- the percentage of population that lies below the national poverty threshold.

In the Pluri national state of Bolivia, up to 83 per cent of smallholders are poor as compared to national poverty average of about 61 per cent. In Ethiopia, where 30 per cent of the entire population lives under the national poverty threshold; the poverty headcount ration of smallholder is 48 per cent (FAO, 2015).

Smallholder with their work on their land and a multiplicity of jobs off-farm earn a diversified income. According to FAO report, Tanzania and Ethiopia both are arid or semiarid sub Saharan countries. In these countries, small farmers generate meager amounts as compared with countries in Asia and Latin America. In Ethiopia, smallholder families earned $ 0.8 per person per day from a farm of about 0.9 hectares. But, larger farmers who are cultivating 3.5 hectares on average can earn about twice ($2.1 per person per day). Ethiopian smallholding household generates the bulk of income from own crop and livestock production (72 percent) and 14 percent from off - farm sector labor (FAO, 2015).

On average, a small family farm in Ethiopia generates a gross annual income about 1246 USD. Agriculture is by far the main occupation for Ethiopia smallholding with on-farm income accounting 79 percent of income and crop production being the most frequent (62 percent*)* (FAO, 2018).

When we define the concept of productivity, it is better to make clear the difference between production and productivity. Production refers to the volume of output while productivity signifies the output in relation to resource expanded. Production can be increased by employing more resources without increasing productivity. On the other hand, productivity can be increased without increasing production by employing less input for the same production level (OECD, 2001).

Another factor that contributes for the income of smallholder households is productivity. Productivity is commonly defined as a ratio between the outputs and the volume of inputs. Productivity is measured on how efficiently production inputs are utilized, for instance, how efficiently labor and capital are used in an economy to produce a given level of output (OECD, 2001).

Land, labor and capital are various aspect of agricultural productivity. These are the best known partial productivity measures; land is viewed as area with different natural attributes. It realizes different rents and varies in purchase price. Labor represents all human services other than decision making and capital the non-labor resources employed by one farmer.

The majority of the world's poor live in rural areas; 70 per cent of the rural poor working in agriculture, so boosting up agricultural productivity will be critical to lifting these households out of poverty (World Bank, 2017). Africa has long been a concern both on account of the very low of land and labor productivity across much of the continent, and because increases in productivity have been slows (Growth research program, 2015).

Agriculture as an example of slow productivity growth, Cereals yields, for example, have grown far more slowly in Africa to those seen in earlier transformers industrialized countries in Asia and Latin America (ACET, 2014). Different report showed per capita GDP product in sub-Saharan Africa increased by almost 35 percent in real terms from 2000 to 2014, doubling in some countries. Meanwhile, aggregate agricultural productivity growth remained low.

Partially measures of productivity of land and labor provide some insights. From 1970 to 1984 yields per hectare rose in sub-Saharan Africa, but output per worker (economically active in agriculture) subsequently yields increased slowly until 2000 after which they grown more rapidly. Productivity is, however, rose considerably from 1984 through mid – 2000s, since when it has apparently fallen back a little (Nin Pratt *et al.,* 2012).

Climate change is likely to cost developing countries up to 19% of their GDP by 2030 (Nelson *et al.,* 2009) and this projection supported by different studies by determining the magnitude and direction of impacts of climate change on Ethiopia agriculture show that climate change poses a statistically significant impact on agricultural production.

Deressa and Rshid (2009) reported that increasing temperature during winter and summer reduces the net revenue per hectare by 997.85$ and 1277.28$, respectively. Additionally, increasing temperature during spring and fall increases net revenue by 375.83$ and 1877.69$ respectively. Once again this reported, increasing the annual temperature reduces the net revenue per hectare by 21.61$. Increasing precipitation during spring increases the net revenue per hectare by 225.08$ and increasing precipitation during winter significantly reduces the net revenue by 464.76$. Marginally, increasing precipitation during summer and the fall also reduce the net revenue per hectare by 18.88$ and 64.19$ respectively.

2.6. Interrelation between Climate smart agriculture and food security and income

Despite the attention paid to agricultural development and food security over the past decades, there are still about 800 million undernourished and 1 billion malnourished people in the world. At the same time, more than 1.4 billion adult are overweight and one third of all food produced is wasted. Before 2050, the global population is expected to swell to more than 9.7 billion people (FAO, *et. al.,* 2018). Agriculture can help to reduce poverty, raise income and improve food security for 80% of the world poor, who live in rural areas and mainly in farming (World Bank, 2017). Certainly, it is estimated that about 75% of the world's poor lives in rural areas, with agriculture being their most important income source *(*Lipper2014)*.* Agricultural growth is often the most effective and equitable strategy for both reducing poverty and increasing food security (FAO, 2014).

However, agriculture in SSA is vulnerable to climate variability. Scientific evidence shows that climate smart agriculture is the key strengthen the farmers' income and sustain food security under the new realities of climate change (Lipper *et al.,* 2014).

Climate change affects agriculture in a number of ways: including through changes in average temperature, for example crop yields show a strong correlation with temperature change and with the duration of heat or cold waves and differ based on plant maturity stage during extreme weather events (Yohannes, 2016).

Climate smart agriculture present opportunity for addressing impact of climate change mentioned above; simultaneously supporting economic growth and development of agricultural sector resulted in ensuring food security. Hence, Ethiopian farmers have begun to adopt new improved technologies and practice in both crop and livestock production systems. For crop production, there are efforts to promote organic fertilizer use and precise fertilizer application as opposed to the use of blanket fertilizer recommendations. When using improved (drought and heat-tolerant) cereal varieties (teff, maize, sorghum, wheat and barley) and crop rotations are increasingly being practiced (FAO, 2016).

Many scholars agree upon the contribution of increasing productivity and income for food security of smallholder households. Raising agricultural productivity and income in the smallholder production sector is crucial for reducing poverty and achieving food security, as a key element and driver of economic transformation and growth and within the broader context of urbanization and development of anoff - farm sector.

The CSA approach is designed to identify and operationalize sustainable agricultural development within the explicit parameters of climate change, While contributing to mitigate climate change and preserving the natural resource base and vital ecosystem, services requires the transition to agricultural production systems that are more productivity, use inputs more efficiently, have less variability and greater stability in their outputs and are more resilient to risks, shocks and long-term climate variability (FAO, 2017).

Enhancing soil quality can generate production, adaptation and mitigation benefits by regulating carbon, oxygen and plant nutrient cycles, leading to enhancing resilience to drought and flooding, and to carbon sequestration. These supply-side changes need to be complemented by efforts to change consumption patterns, reduce waste and create positive incentives along production chain (Bruce *et al.*, 2014).

Generally, climate smart agriculture build on existing efforts to achieve sustainable agriculture intensification such as sustainable crop production intensification (FAO, 2001), CSA will sustainably intensify production system to achieve productivity increases thereby supporting the achievement of national food security and development goals, increase the resilience of production system and rural livelihood (Adaptation) and reduce agriculture's greenhouse gas emissions(including through increased production efficiency) and increase carbon sequestration (mitigation) (FAO, 2013).

Climate smart agriculture production technologies are therefore aimed at maximizing food security benefits and at the same time, deliver significant climate change mitigation and adaptation co-benefits (Branca *et al.*, 2011).

2.5. Empirical Review

Various literatures showed that factors that determine food security at household levels in rural areas. Bashir and shilizzi (2030) take into account three components on their review of determinants of food security in Africa and Asia hence education and age of household head's age, input availability, technology adoption, farm size, land quality, price of inputs and credit have been identified as determinants of the availability component of household food security. Factors like income, distribution of income within the household, household size, total earning members and family structure are identified as determinants of the access aspect. Finally, gender and expenditure on food and health are considered as determinants of utilization aspect

(Gebre – selassie 2005) On his working paper in south and north Wollo of the Amhara national regional state, logit regression model describes Number of children less than 7 years old, number of person between 7 – 14 years, number of person between 15 – 50 years, age of household head are significant and positively affect food security of the household.

Another studies, which was done by Demeke and Ramakrisha (2002) in North Wello, the result of logit model reveals that educational, fertilizer consumption, livestock, land size and cereal production has positively affect food security, implies reduce the probability that households are food insecure. The result of kidane *et al.*,(2005) present from logistic regression that access to fertilizer, educational level of household heads, access to land and access to family planning would affect positively to improve status of food security in Oromia region of Ethiopia by using the rural household survey data.

Similarly, Jemal and Kim (2014) empirical analysis on determinants of household food security in rural Ethiopia, the result of ordinary least square estimation result showed household age, level of the education of the household head, rain fall index, livestock possession, participation in off farm activates and per capita consumption expenditure were found to have a significant positive influence on household food security.

Smallholder with their work on their land and opportunity of jobs off-farm earn a diversified income, according to FAO report, Tanzania and Ethiopia both arid or semiarid sub Saharan countries small farmers generate meager amounts as compared with countries in Asia and Latin America, in Ethiopia smallholder families with a farm of about 0.9 about $ 0.8 per person per day. But larger farmers cultivating 3.5 hectares on average although they make about twice as much ($2.1 per person per day) are not well of either. Ethiopian smallholding household generates the bulk of its income from its own crop and livestock production (72 percent) and 14 percent from off - farm sector labor (FAO, 2015).

Income diversifications patterns are different smallholders rely more on crop and livestock income rather than on off-farm labour. An Ethiopian smallholding household generates the bulk of its income from its own crop and livestock production (72%) and about 14 percent from off - farm sector labour. Transfer and remittances make up 6.1% and off farm agricultural labour a negligible 2%. Given the low productivity of Ethiopian smallholders it would make sense that they should pursue off - farm employment opportunities more actively. And they do-about three family members work off-farm per day, in an economic environment characterized by the lack of markets and opportunities. The job they do day little. The average daily off - farm sector employment returns in Ethiopia amount to $1.30 as compared with $3.20 in Bangladesh (FAO, 2010).

The prevalent explanation is that with income diversification, smallholders reduce their exposure to risk. The possibility of adverse shocks, such as droughts, makes smallholder families to seek employment outside the agricultural sector to hedge against climatic and other market risks. Nevertheless for many, income from crop and livestock production only is not enough to cover the basic needs of the family.

According to Haji (2008), increased productivity has a number of advantages. Firstly, it increases the flow of resources from one sector to the other, thereby enhancing economic growth. Secondly, a higher level of agricultural productivity results in lower food prices that increase consumer' welfare. Thirdly, productivity growth improves the competitive position of a country's agricultural sector.

Akram Naz and Ali(2011), in Pakistan finds that the increases of land holding size, the level of household head education, the household rental income and non- farm occupation are significantly increase the rural household incomes; the study used semi log multiple regression model to analysis cross – sectional data. Aikaeli (2010), study the determinants of rural income in Tanzania, find that as the size of family labor force, cultivated land size for farm income and educational level of the household head increases, the per capital income of the rural household is significantly increased.

Most of African agriculture is traditional and characterized by labor intensive production and excess demand for labor often occurs during period of land preparation, weeding and harvesting (Urgessa, 2015), this implies that labor size has also impact on the increasing productivity.

Many of the studies conducted recently suggest that land has a major influence on production positively; Mushunje, *et, al.*,(2003) find positive coefficient in land significant at all levels, on study relative technical efficiency of cotton farmers in Manica land province of Zimbabwe. In Ethiopia also Fufa and Hassan (2003) find that the estimated coefficient of land is positive and significant. We can understand from this positive influence of land on agricultural production and income, due to theoretical literatures suggests that the agricultural productivity is essential for household income improvement.

Berg and Kumbi (2006) finds that agriculture was the main source of rural income inequality in Oromia national state of Ethiopia, according to their result, 90 percent of total inequality was due to farm source of income. Reversely off - farm income was found to be inequality decreasing source of rural income.

In Africa, CSA is used on less than one million hectares, accounting for less than 1% of the total global area under CSA management (Milder *et al.,* 2011). This limitation arises from different reason, such lack of potential to use systematic response to climate change through adoption of CSA practice and technologies.

Based on the World Bank categorization of CSA practices (weather, water, carbon, nitrogen, energy and knowledge), Ethiopian farmers are more likely to engage in soil conservation, use different crop varieties and change planting dates as farm income increases. Off - farm income increases the likelihood of planting trees, changing planting dates and using irrigation as adaptation option. Additionally, ownership of livestock significantly increases the probability of adapting to climate change (Temesgen, 2016).

Empirical studies those done at abroad and locally have identified common variables that affect the probability that smallholder farmers will adopt CSA. According to (Samuel *et al.,* 2019) determinant of CSA adoption among smallholder food crop farmers; Economic, environmental, socio-cultural, personal and institutional factors are identified. Adoption rate also determined by subjective variables such as farmer's awareness of new practices, personal willingness and over all concern for the problem the practices aim to address (Below *et al.*, 2010).

Economic related issues which include financial availability demand farm produce, access to labor as well as available sustainable agriculture technologies (economic factor) influenced farmer's adoption of CSA. Farmers need support at various levels to be able to embrace CSA; the marginal effect estimate indicated that years of education of the respondents and membership of a social group were significant explanatory variables that influence the usage of CSA among the user and non-user categories. Access to credit also influenced the usage of CSA practices among the non-user and user categories (Emmanuel *et al.*, 2017).

CSA in Ethiopia very significant for the various reasons like role for ensuring food security and increase income, for example, this has the potential to alleviate food insecurity among smallholder farmers if used in combination and to a larger extend. Farmer should then be encouraged to incorporate larger CSAs packages which comprise at least member in each of the four categories; crop management, risk reduction practices and specific soil management practice, to have a higher effect on food security (Jirat *et al.*, 2016).

To contribute for local research need this study aimed to identify adoption effect of CSA on food security and income of household and to identify factors affect the adoption of CSA at study area, this research contributed in some way to fill the gap.

Theoretical Review

Why, how and at what rate new agricultural practices can be adopted by household farmers explain by the following theories, economic constraints, technology characteristics user's context and the innovation diffusion theory.

The technology characteristics-user's context theory

The technology characteristics user's context theory integrates approaches which assume that characteristics of a technology under lying users' agro-ecological, socio economic and institutional context has important role in the adoption decision and diffusion process (Biggs, 1990; Scoones and Thomson, 1994). This model consider the perception of potential adopters regarding the characteristics of technology as a component affecting adoption decisions and hence the diffusion of the technology (Gouldet *et al*,. 1989). The importance of policies and strategies that facilitate the participation of farmers and other development actors in the technology development process indicates in this model.

The economic constraints theory

The model supposed that market prices (induced by policy and institutional interventions) reflect the relative scarcity of the factors, implying the existence of (or need for) well-performing markets and the importance of prices policies (Hayami and Ruttan 1971). Generally the notion of this model, known as the factor endowment model, is that the distribution of resource endowments among the potential users in a country determines the pattern of adoption of a technological innovation.

The Innovation-diffusion theory

According to this theory, a technology is transferred from its source (research system) to final users through agent medium (extension systems) and its diffusion in potential user communities depends mainly on the personal characteristics of the potential individual user (Tewodros, 2018).This theory assumed that the technology is appropriate for use unless hindered by the lack of effective communication. This study is mainly depending on this theory.

2.6. Conceptual Framework

In the regard of climate change challenge and damage, climate adaptation and mitigation are crucial though to manage as well the impact combination of two strategies were very important. In agriculture sector, there is high potential of synergies between climate change adaptation and sustainable development (FAO, 2008). Adaptation advantages are not limited with climate change but also will help in socio economic development.

The economic benefits of adaptation are many: sustained or increased agricultural production, higher household income, enhanced environmental services, protection of the asset base, and less vulnerability to extreme weather events (IFAD, 2013). The adaptation practices and effective adaptation policies will help to increase farming capacity and food system in the face of climate change and maintain food production.

The general explanation theory mainly emphasizes on the impacts of drought, flood, land degradation, inaccessibility to productive resources and pressure on the performance of household food security status (Degefa and Meskerem, 2015); hence to minimize climate change challenges adaptation mechanism has great role to secure or improve household status

Adaptation will requires the involvements of multiple stakeholders, including policymakers, extension agents, NGOs, researchers, communities and farmers (IPCC, 2014). Climate smart agriculture practices adoption status is mostly location specific and socioeconomic setting. However, Adoption climate smart agricultural practice influenced by demographic, socio-economic and institutional characteristics of the farmers. Demographic characteristics such as age, total members of household, sex and educational status of household head, and socioeconomic characteristics such as land and livestock ownership of the household and income source of household, with the regard of institutional factors availability of infrastructure, access to extension agents, access of information on climate change and market information and participation of farmers in social and formal institutions affects farmer decision to adopt climate smart agricultural practices. Farmers' decision capacity affected by demographic characteristics, in addition to this farm size, income, access to markets, access to climate information and extension and livestock production influenced positively (Abreham *et al.,* 2017).

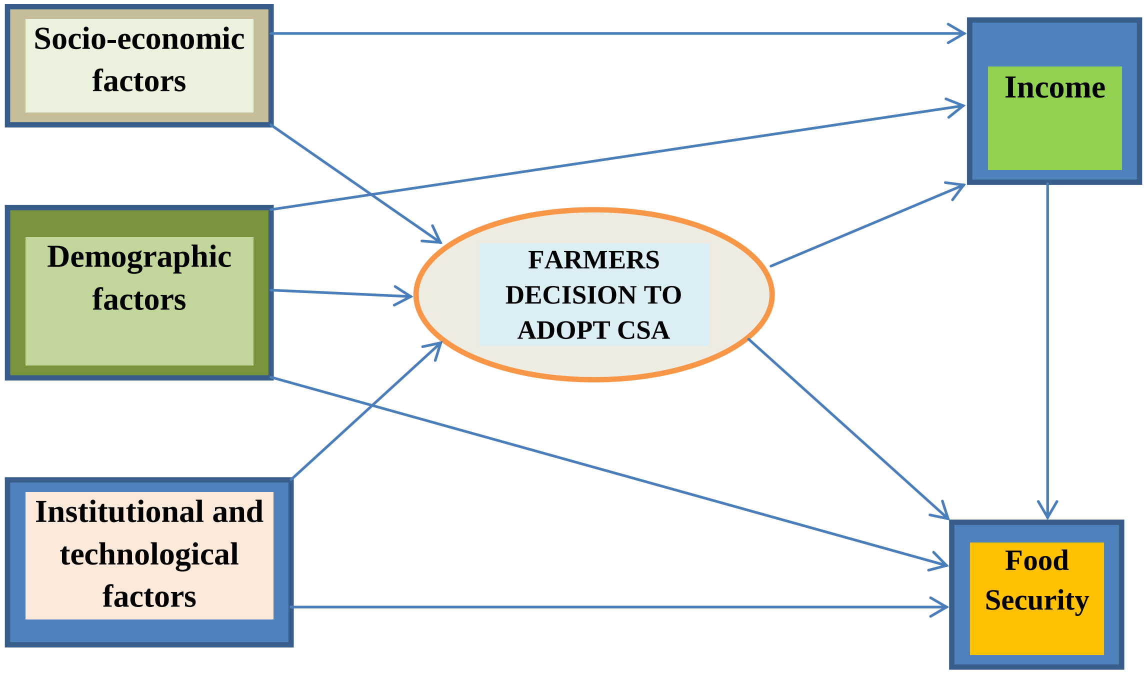


Figure 1: Conceptual Framework (Own Constructed)

3. RESEARCH METHODOLOGY

3.1. Brief description of the study area

This study was carried out in the Gimbichu woreda potential agricultural region of East shewa. Gimbichu woreda is one of the 11 Woreda of East Shewa Zone, Oromia national regional state. The capital of the woreda called Chafe Donsa, located at about 87 kms from Addis Ababa to the East. The woreda is located at 8º 56' 09" N, 39º 08' 53" E and at 2287 M altitude, majority part of the woreda are highland more than 2300 meters above sea level. Gimbichu woreda is bordered on the east by Afar region, by northwest by the Amhara region, on the southwest by Ada'a chukala and by south by Lome woreda. The total area coverage of the woreda 707.49 square kilometer and the woredas land use looks like 37.6% is cultivable, 14.2% pasture, 2.6% forest and the remaining 45.6% is considered degraded lentils, chickpeas are important cash crop (GOOR, 2010).

According to the data obtained from the woreda administration office, there are 4 urban and 33 rural kebele available under this woreda administration. The population projection by Central Statistical Agency, 2013 reported a total population of 90,311 in this woreda of which 46483 males and 43828 females. There were 14 farmers service cooperative with 10,207 members and woredas has 119 km of dry weather and 26 km of all-weather roads.

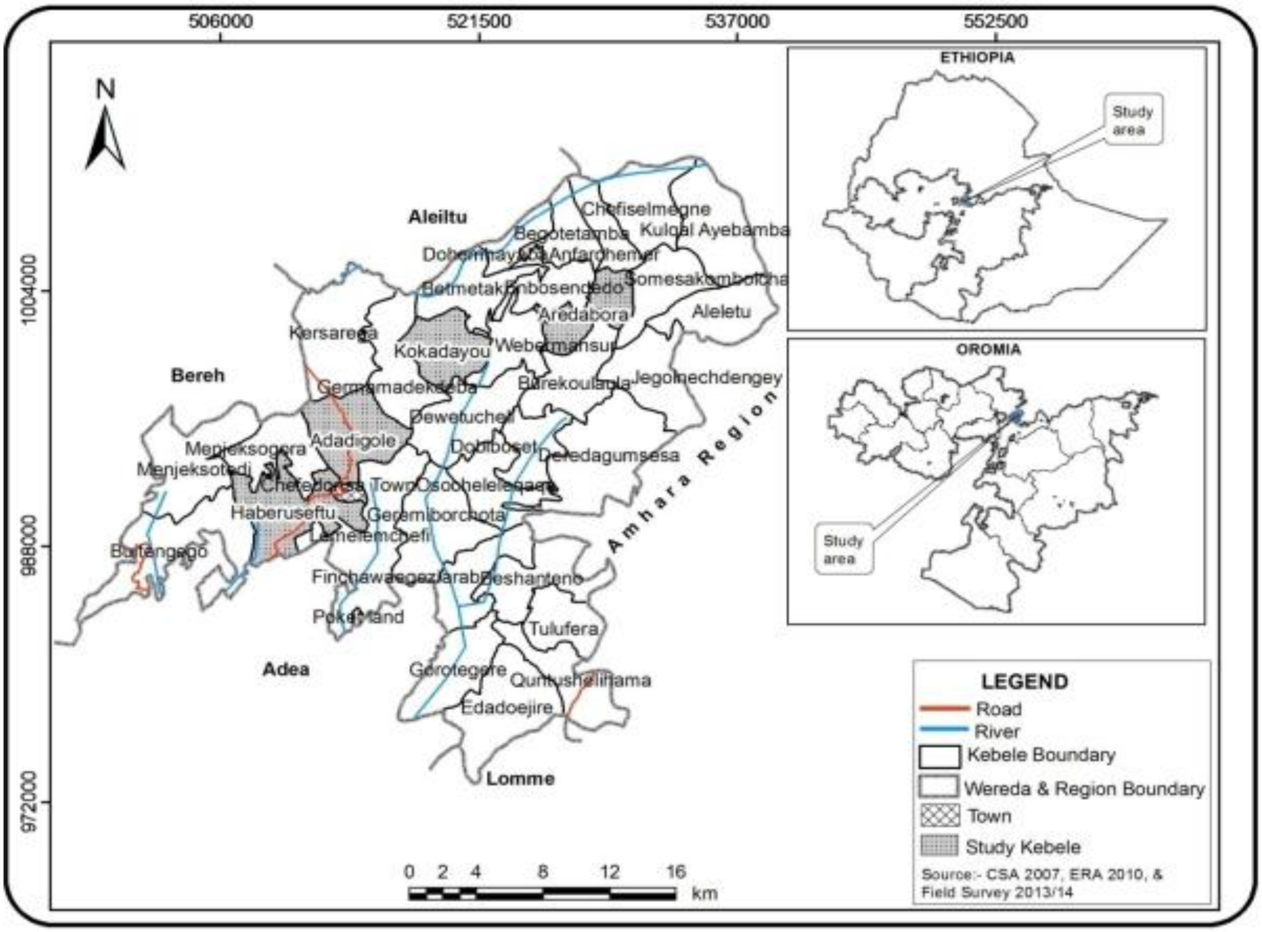


Figure2. Study area map (source: 2007)

June to September is the referred as main rainy season, there are two main seasons: Genna is a main rainy season which extends from June to September and Bona the period that extends from October to may. The Genna rains are used for planting long and short cycle crops, maize, the long cycle crop, is grown from May to December. Teff and wheat, short cycle crops are grown from July to November (Engdawork,2015). Rearing Livestock like cattle sheep, donkey, horses, poultry etc are also another livelihood activity in addition to crop production.

Regarding the soil textural class is heavy clay and soil types was Eutricvertisol, vertisolis cover about 14.6% of the district. The district is with hot to warm sub-humid climate (NMA, 2007). The area is characterized by mean annual rainfall of 900mm and temperature of 17^0c (Teklu *et al.*,2006). Gimbichu woreda is well-known for teff and wheat production and representation of different agricultural activities are among the reason for selection of this woreda for this study.

3.2. Research Design

This research employed descriptive and analytical cross sectional study design. This help to analyze data of variables that are collected at one given point of time across a sample population. Multistage sampling technique was employed; the step involved the selection of woreda purposely followed by randomly selection of the kebeles. Sampled household were randomly selected from the perspective total number of households found in three kebeles.

3.3. Types and Sources of Data

The data that applied in this study include both primary and secondary data which was collected by using a structured questionnaire and an assessment of various relevant documents respectively. Accordingly, the source of primary data information that can be collected through structured questionnaires and in depth interview from the respondents (smallholder farmers); whereas secondary data would be the different documents about climate smart agriculture practice that obtained from various publications.

3.4. Sample and Sampling techniques

As mentioned above under the description of study area section, Gimibichu woreda contains 33 rural kebeles and 4 urban kebeles; hence the study was applying multistage sampling technique. The sample kebele were stratified based on their agro ecological zones. Next, purposive sampling was employed to select kebeles for this research purpose to conduct study based predominantly known by Teff and wheat producer according to the information that are obtained from woreda agriculture office. Based on this, the specific kebeles that are considered in this study includes Girmi Borchota, Usoo Chalalaka and Habru seeftu.

3.5. Sample size determination

Gimbichu woreda contain 33 rural kebeles, accordingly studying this number of population is very difficult because of time and budget constraints. Hence, the number of sample smallholder households that would be considered for interview was selected based on the proportion of households in each selected kebele.

A simplified formula provided by (Yamane,1967) to determine the required sample size at 93% confidence level, degree of variability =0.5 and level of precision = 7% (0.07), hence we use this level of precision due to there was time, resource limitation and data collection procedure was challenged due suspension of mobility due to COVID 19 pandemic.

$$n = {}^{N}\!/_{1 + N(e2)}$$

Where n=the required sample size

N=population size (2040)

e= is the level of precision (0.07)

The number of sample households (the number of respondents for the household questionnaire survey) was determined to be about 204 households are the sample sizes. The total sample size has been distributed to each sample kebele based on the proportion of total number of households in each selected kebele.

Table 4. Sample size allocation

Kebeles	**Total household**	**Total sample household**
Girmi Borchota	811	85
Usoo Chalalaka	785	82
Habruseeftu.	444	37
Total	2040	204

3.6. Data collection procedure

The study participant was peasant association (PA). Hence, close ended questionnaires in the form of yes/no, agree/disagree and a scale was used for quantitative data. This would be done by setting, organizing and applying the all necessary steps and procedures that should be put under consideration and administers through face to face contact and interviewing household head.

The household survey questionnaire helps to gather quantitative information at household level, this toll was amended and enumerators fluent Afan Oromo were recruited and trained before engaging data collection process. In addition to my experience on research assistant's; professionals and agricultural officers working in perspective issue were contacted for the detail understanding of the study area household status and general aspect such as socioeconomic condition among others.

The structured questionnaire had five main parts. section one focused on household demographic characteristics, section two related socio economic status of households, section three related with household food security information, section four access about household access of institutions and the last section focus on the household adoption intensity of climate smart agriculture practices and measuring perception on the climate change.

3.7. Methods of data analysis and interpretation

The collected data would be analyzed by triangulating the information gathered by using various tools accordingly. Hence, the data collected from in review of secondary data secondary data would be analyzed and interoperated by using words, clauses and sentences qualitatively whereas data gathered from close ended questionnaires will be analyzed by using statistical software called STATA 13.

3.7.1. Descriptive data analysis

This method of data analysis includes ratios, percentages, mean and standard deviation. The research would use this method to summarize and presents demographic, socio-economic and institutional factors that will collected from sample household through survey questionnaire.

3.7.2. Econometrics Analysis

Econometrics analyses are used to draw conclusions about the reliability and generalizability of the findings. In order to test the research hypotheses, the inferential tests used include Multiple Regression Analysis (MLR).

Econometric data analysis model has been used to identify factor affecting adoption intensity of the farmers' to response to climate change and variability, and again to test the effect of adoption intensity of the practices on the food security and income of the households the research employee MLR model. The Multiple linear regression models was used to answer the research question related to specific objectives of Assess the Adoption intensity of CSA on Food Security and Income of Smallholder households and to identify the factors that affect the adoption intensity of CSA practices

Linear regression is a statistical analysis which used for modeling a relationship between two kinds of variables, dependent (response) and independent (predictor). The main purpose of regression is to examine if the independent variables are successful in predicting the outcome variable and which independent variables are significant predictors of the outcome.

Multiple linear regression (MLR), also known simply as multiple regression, is a statistical technique that uses several explanatory variables to predict the outcome of a response variable. The goal of multiple linear regressions (MLR) is to model the linear relationship between the explanatory (independent) variables and response (dependent) variable. In essence, multiple regressions are the extension of ordinary least-squares (OLS) regression that involves more than one explanatory variable. In other words, multiple linear regressions (MLR) can be described as a mathematical relationship among a number of random variables. In other terms, MLR examines how multiple independent variables are related to one dependent variable. Once each of the independent factors has been determined to predict the dependent variable, the information on the multiple variables can be used to create an accurate prediction on the level of effect they have on the outcome variable. The model creates a relationship in the form of a straight line (linear) that best approximates all the individual data points.

Multiple Linear Regression Model:

$y = \beta 0 + \beta 1\ x1 + \beta 2\ x2 + ... + \beta v\ Xv + \varepsilon$

Where y = an observed value of the response variable for a particular observation in the population

β_0 = the constant term

β_j = the coefficient for the jth explanatory variable (j = 1, 2, …, v) j x = a value of the j th explanatory variable for a particular observation (j = 1, 2, …, v)

ε = the residual for the particular observation in the population

For this study case, y= observed value of the response variables (Food security, Income and CSA intensity) was explained by the j_{th} explanatory variables (sex, age, education, fmly_size, working_age, hectare, TLU, fertility, irrigation, extension, weather_info, market_info, distance_sell, distance_buy, institutions, off - farm income, CSA).

Explaining Multiple Linear Regression

A simple linear regression is a function that allows an analyst or statistician to make predictions about one variable based on the information that is known about another variable. Linear regression can only be used when one has two continuous variables an independent variable and a dependent variable. The independent variable is the parameter that is used to calculate the dependent variable or outcome. A multiple regression model extends to several explanatory variables.

Assumptions of multiple linear regression models

The multiple regression models are based on the following assumptions:

- There is a linear relationship between the dependent variables and the independent variables.
- The independent variables are not too highly correlated with each other.
- Yi observations are selected independently and randomly from the population.
- Residuals should be normally distributed with a mean of 0 and variance $\sigma 2$.

The coefficient of determination (R-squared) is a statistical metric that is used to measure how much of the variation in outcome can be explained by the variation in the independent variables. R^2 always increases as more predictors are added to the MLR model even though the predictors may not be related to the outcome variable. R^2 by itself cannot thus be used to identify which predictors should be included in a model and which should be excluded. R^2 can only be between 0 and 1, where 0 indicates that the outcome cannot be predicted by any of the independent variables and 1 indicates that the outcome can be predicted without error from the independent variables.

Model building

Y (Food Security) = β_0 + β1 Sex +β2 age + β3 education + β4 fmly_size + β5 working_age +……..+ β16 CSA + ε

Y (Income) = β_0 + β1 Sex +β2 age + β3 education + β4 fmly_size + β5 working_age +……..+ β16 CSA + ε

Y (CSA intensity)=β_0 + β1 Sex +β2 age + β3 education + β4 fmly_size + β5 working_age +……..+ β15 institution + ε

Parameter Interpretations in Multiple Linear Regressions

When interpreting the results of a multiple regression, beta coefficients are valid while holding all other variables constant ("all else equal"). The output from a multiple regression can be displayed horizontally as an equation, or vertically in table form.

Estimates of the Model Parameters

- The estimates of the β coefficients are the values that minimize the sum of squared errors for the sample. The exact formula for this is given in the next section on matrix notation.
- The letter *b* is used to represent a sample estimate of a β coefficient. Thus b_0 is the sample estimate of β0; b_1 is the sample estimate of β_1, and so on.

Fitted Values and Residuals

Analysis of residual is an effective way to discover several type of model adequacy. It is a measure of variability y that is left unexplained by the regression model. Thus, any departures from the assumptions on the errors should show up in the residuals.

- A fitted (or predicted) value is calculated as $\hat{y}_i=b_0+b_1x_{i,1}+b_2x_{i,2}+\ldots+b_kx_{ik}$, where the *b* values come from statistical software and the *x*-values are specified by us.
- A residual (error) term is calculated as $e_i=y_i-\hat{y}_i$, the difference between an actual and a predicted value of *y*.
- A plot of residuals versus fitted values ideally should resemble a horizontal random band.

Significance Testing of Each Variable

Within a multiple regression model, we may want to know whether a particular *x*-variable is making a useful contribution to the model. That is, given the presence of the other *x*-variables in the model, a particular *x*-variable help us predict or explain the *y*-variable. For instance, suppose that we have three *x*-variables in the model. The general structure of the model could be

$y=\beta_0+\beta_1x_1+\beta_2x_2+\beta_3x_3+\epsilon$.

As an example, to determine whether variable x_1 is a useful predictor variable in this model, we could test:

$H0;:\beta1=0$

$Ha : \beta1\neq0$.

If the null hypothesis above were the case, then a change in the value of x_1 would not change *y*, so *y* and x_1 are not linearly related. Also, we would still be left with variables x_2 and x_3 being present in the model. When we cannot reject the null hypothesis above, we should say that we do not need variable x_1 in the model given that variables x_2 and x_3 will remain in the model. In general, the interpretation of a slope in multiple regressions can be tricky. Correlations among the predictors can change the slope values dramatically from what they would be in separate simple regressions.

To carry out the test, statistical software will report *p*-values for all coefficients in the model. Each *p*-value will be based on a *t*-statistic calculated as

$$t^*= \text{(sample coefficient - hypothesized value) / standard error of coefficient.}$$

For our example above, the *t*-statistic is:

$$t*=(b_1-0)/se(b_1)=b_1/se(b_1).$$

Note that the hypothesized value is usually just 0, so this portion of the formula is often omitted.

The p-values test whether or not an observed relationship is statistically significant. The p-values less than or equal to 5% show the corresponding predictor variable is significant at the significant level. Compare this p-value to your α-level. If the p-value is less than or equal to the α-level you have selected, the association is significant. A commonly used α-level is 5%.

- ✓ If the p-value is less than or equal to the α-level, then the association is significant, and conclude that at least one predictor is significantly associated with the response
- ✓ If the p-value is greater than the α-level, then conclude that there is no significant association and the interpretation ends.
- ✓ If the p-value is greater than the α-level, then conclude that there is no significant association and the interpretation ends.

Multiple linear regressions, in contrast to simple linear regression, involve multiple predictors and so testing each variable can quickly become complicated. For example, suppose we apply two separate tests for two predictors, say x_1 and x_2, and both tests have high p-values. One test suggests x_1 is not needed in a model with all the other predictors included, while the other test suggests x_2 is not needed in a model with all the other predictors included.

Interpretation of the Model Parameters

- Each β coefficient represents the change in the mean response, E(*y*), per unit increase in the associated predictor variable when all the other predictors are held constant.
- For example, β_1 represents the change in the mean response, E(*y*), per unit increase in x_1 when x_2, x_3,..., x_k are held constant.
- The intercept term, β_0, represents the mean response, E(*y*), when all the predictors x_1, x_2, ..., xk, are all zero .

One way ANOVA

One way ANOVA is used to check whether there is any significant difference between the means of three or more unrelated groups it mainly tests the null hypothesis.

H_0:$\mu 1 = \mu 2 = \cdots = \mu k$ where μ means group mean and x means number of groups.

This study use ANOVA analysis to test whether the adoption intensity of CSA practices has effect on the food security status of households, for this study case:

$H0$:μ *food secure)*=μ*(mildly food insecure)*=μ*(moderately good insecure)*= μ*(high food insecure)*= μ*(severely food insecure)*

The alternative hypothesis (H_a) is that at least one group mean significantly differs from the other group means. Or – that at least two of the group means are significantly different.

H_a:$\mu_i\mu_k$for some *i*, *k*; where *I* and *k* simply indicate unique groups.

Assumptions under one-way ANOVA

1. The observations are random and independent samples from the populations. This is commonly referred to as the assumption of independence. The null hypothesis actually says that the samples come from populations that have the same mean. The samples must be random and independent if they are to be representative of the populations. The value of one observation is not related to any other observation. In other words, one person's score should not provide any clue as to how any of the other people should score. That is, one event does not depend on another.

2. The distributions of the populations from which the samples are selected are normal. This is commonly referred to as the assumption of normality. This assumption implies that the dependent variable is normally distributed (a theoretical requirement of the underlying distribution, the F distribution) in each of the groups.

3. The variances of the distributions in the populations are equal. This is commonly referred to as the assumption of homogeneity of variance.

3.7.3. Measurements of outcome variables

In the study food security and income are outcome variables that follow adoption of climate smart agriculture practices and their intensity

***Household Food security*:** Food security of measured by Household Food Balance Model, adopted by Degefa (1996) from FAO Regional Food balance Model was used. The conversion of the net available food into dietary calorie equivalent was based on Ethiopian health and nutrition research institute's food composition table.

Expression of HFBM is:

$$NGAij = (GPij + GBij + FAij + GGij) - (HLij + GUij = GSij + GVij)$$

Where;

NGA_{ij}= Net grain available by i^{th} household in year j

GP_{ij}= Total grain produced by i^{th} household in year j

GB_{ij}= Total grain bought by i^{th} household in year j

FA_{ij} = Quantity of food aid obtained by i^{th} household in year j

GG_{ij} = Total grain obtained through gift or remittance by i^{th} household in year j
HL_{ij} = Post harvest loosed by i^{th} household in year j
GU_{ij} = Quantity of grain reserved for seed by i^{th} household in year j
GS_{ij} = Amount of grain sold by i^{th} household in year j
GV_{ij} = Grain given to other by i^{th} household in year j.

All food grain have naturally their own calories constant, based on the Ethiopia health and nutrition research institute's(ENHRI) in the (Appendix VII) summary table present the average dietary caloric with respect to the grain type commonly consumed in the study area.

Accordingly the available grain supply was converted into its equivalent calorie using EHNRI's food composition table, used this standard deliberately because of calories equivalent of the grain varies by the kind of the end products prepared for consumption.

Dietary energy analysis is an important indicator of food adequacy level of household. It is the per capita dietary energy supply measured in calorie. It provides the average daily food available for each person in a country or region (FAO 1998) and used to comprehend the average dietary calorie in a given area.

In fact the dietary energy depends on different characteristics like sex, age, body weight, health condition and physical activity, to minimize this kind of variation among the sampled household using average value simplify the complexity happen during analysis available daily dietary energy supply of household.

Household income: In the model, household income is measured by the following economic model adopted from a joint guidance document of the committee on sustainable assessment (COSA), the ISEAL alliance and the sustainable food lab (2016). To understand and calculate household income effectively and consistently, research was used the below farm economic model represent the individual household income where focus crop for this study is wheat and Teff.

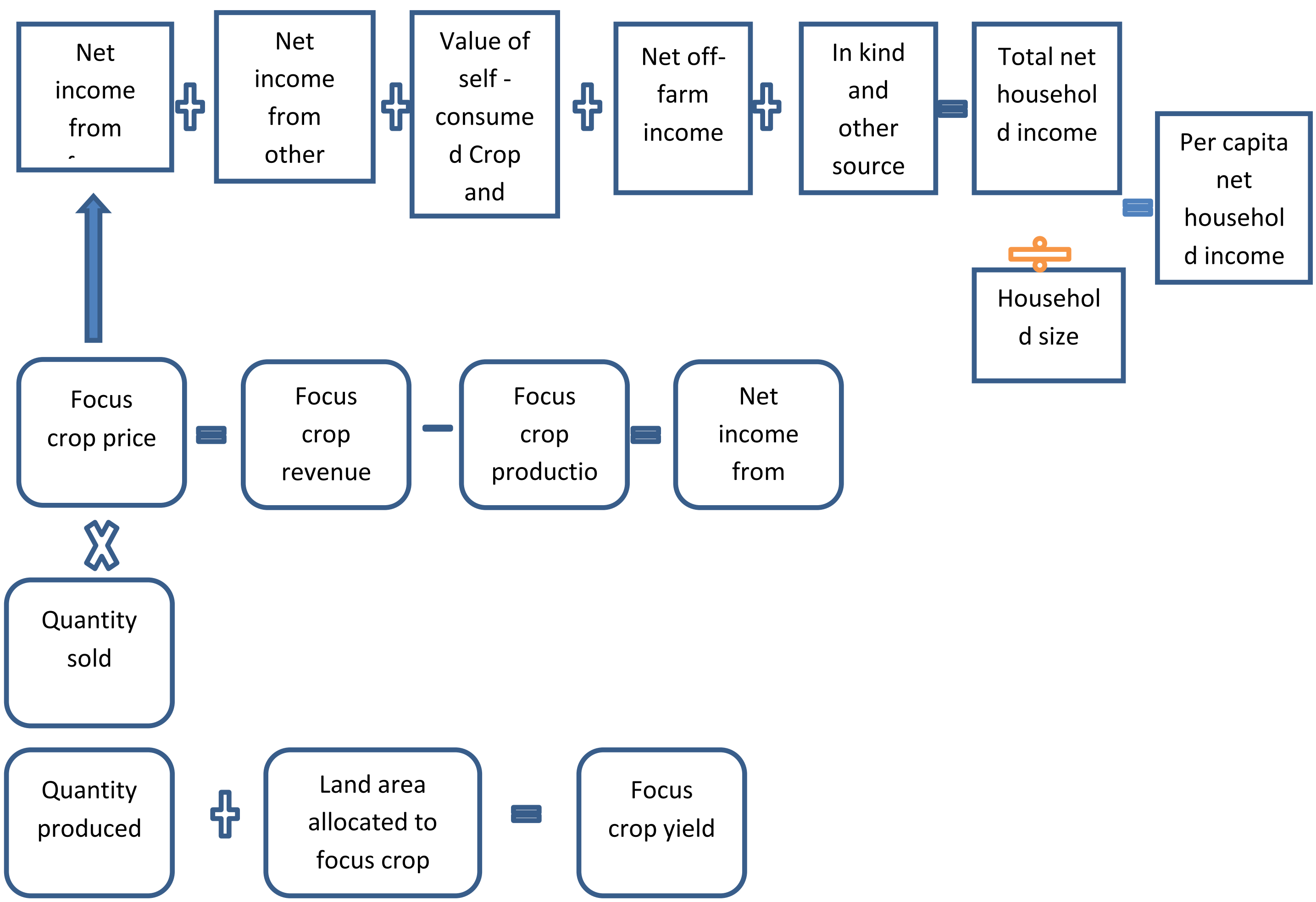


Figure 3: Farm economic model (Adopted from COSA, ISEAL & sustainable food lab)

3.8. Description of variables

3.8.1. Response Variable: Farmers adopt different climate smart agriculture practices on teff and wheat production during production year under study. Based on this study was create adoption intensity level for each household to compare the level regard to the adoption. In view of this, the response variable, Climate smart agriculture practice intensity of the i^{th} household which was measured as a continuous variable.

3.8.2. Predictor Variables: The list of predictor variables which were expected to influence Food security, income and climate smart agriculture practice were all categorical and grouped under three major classes; household demographic characteristics, socio-economic characteristic and institutional characteristics. According different related past research findings, the following predictor variables will consider in this study.

Sex of household head: This variable is dummy variable taking the value 1 if male and 0 female. Research expected sex of household head might have positive or negative relation with adoption of CSA. (Deressa *et al.,* 2008) showed that Male-headed households are found to be more likely to adapt to climate change. Given that men do much of the agricultural work in Ethiopia, they are more likely to obtain information about and have access to new technologies and to take greater risks than female-headed households. This marginalization of female from agricultural investment this study expected female headed households less food secure and less income than male headed households.

Age of household head: In this variable indirectly captures farming experience also influence awareness of and adaptation to climate change, this variable is continuous variable measured in years. The study would hypothesis that age of household head might be positive or negative effect on food security, income and adoption intensity of CSA.

Educational attainment of household head: It is categorical data and takes value as follows 1 if household head is illiterate, 2 literate. Higher level of education is associated with greater access to information on climate change, improved technologies and higher productivity. According (Deressa *et al,* 2008) education increases climate change awareness and the likelihood of soil conservation and changing planting dates as an adaptation method. On the regard of food security and income of household this study expected positive effect. Literate households might be constrained by other factors to productively use their knowhow towards achieving food security (Jemal and Kim, 2014).

Family size: This continuous variable and refers to the total number of family members in the household. Regarding this research hypothesized variable can affect negatively, food security status of household. Implying that household with more family members are more food insecure (Jemal and Kim, 2014).

Family labour size*:* This continuous variable and refer to total number of family members in the household those age between 15 and 65. Study expected positively or negatively affects CSA adoption intensity and income of household. Larger households are more likely to adapt to perceived climate change, probably because they are often associated with higher labor endowments (Deressa *et al*, 2008). So that if there is much active labor force age family member are in the family, the probability generate more income and easily of adopt CSA practices of household become increase.

Land size of household: Which is continuous variable measured in hectares and as different scholars concluded large land size allows farmers to diversify their crops. Due to this fact farm land size would have positive contribution for implementing CSA practices. Available farm resources (land) are too small to provide adequate food and income for the average household (Samuel, 2004), accordingly this research also expected positive effect of farmland size on food security and income of household. Farm size has positive and significant association with most of the adaptation strategies (Abreham *et al.,* 2017). Another study tells also, as the size of farmland increases, the probability of adapting different practices efficiently. Farm size has therefore positively and significantly increased the likelihood of adaptation to climate change (Madison, 2006).

Total livestock ownership: It is continuous variable and this refers to the total of animals possessed by the household measured in tropical livestock unit (Appendix II), as the total number of animals in the household increase, the farmer more likely to adopt CSA. This study expected larger livestock possession positively contributes to household food security as well dairy production has positive contribution for income of household.

Fertility of farm land: It is categorical variable takes 1 for fertile, 2 moderately fertile and 3 less fertile. Knowing about the fertility of the land it helps the farmers' to decide what kind of agricultural climate smart practices such as using compost and inorganic fertilizers, fertility of farmland would have positive impact for adoption to produce adequate production to fulfill need of food; so study expectd positive effect of fertile farmland on food security and CSA adoption intensity. However, knowing the soil texture can provide information about water flow potebtial, water holding capacity and fertility potential of the soil among others.(Degefu, 2013).

Possessing Irrigation: It is dummy variable which takes 1 if household used irrigation practices 0 if not possess irrigation during survey period. Household those possess irrigation during survey production period would expect to increase the probability of household income by diversifying their source of income and again it help them to diversify their source of food.

Frequency Contact with extension agent: It is continuous variable which takes a visiting time by extension agent per agricultural season and this study expected positive effect on the household income and adoption intensity of CSA practice. Although, all farmers may not have equal access to extension services, some farmers visit extension agents more frequently while other visits rarely. This kind of service is essential to promote new technology and to scale up new improved practice such as CSA practices though it leads to increase productivity and income.

Access of market information**:** This is measured as a dummy variable taking a value of 1 if household had access to market information and 0 otherwise. Access to different services has important contribution in improving production and productivity and thereby increasing marketable surplus and ultimately for increasing the income of smallholder farmers (Urgessa, 2011). So access to the market information would affect the household positively to adopt CSA.

Access of weather information: It is dummy variable specifying household can access weather information 1 and 0 if cannot access weather information. If there is access of weather information for farmers' expected to adopt climate smart agriculture, because of they help to practice each activities based on the timely weather information. Access to information on climate change through extension agents, metrological service media and social networks creates awareness and favorable condition for adoption of farming practices that are suitable under climate change also it is important precondition for farmers to adopt climate smart agricultural practices (Abrham et al., 2017).

Distance to the market: This is continuous variable measured in minutes from residence of household to the market center. The residences of farmers are nearest to the market they get a lot of opportunities as compare the far ones (Malefiya, 2017 cited in Demissie, 2018 2017). So that distance to the market of input and where there selling buying activities take place, would have positive impact for the nearest and negative impact for the furthest households.

Off- Farm income: It is a continuous variable measured by an income (birr) that the household generate from non-farm activities during the agricultural production within study period reference. There is expected to a positive relationship with food security, income and food security of household who have off - farm income.

CSA intensity: This is continuous variable measured in adoption intensity score of household used during survey period. Household those who were highly adopted CSA practices during the production period would expect to increase the probability of farm productivity if the can increase productivity it helps them to ensure their food security as well as strengthen financial capacity.

Table 5. Variables description and the variables used for regerssion of determinants of Food security

Variables	**Description**	**Data type**	**Value**	**Expected signal**
Sex	Sex of household head	Dummy	1=Male 0=Female	+ve or -ve
Age	Age of Household Head	Continuous	Number of years	+ve or –ve
Educational status	Educational attainment of household head	Categorical	1= Illiterate 2=Literate	+ve
Fmly_size	Total member of household	Continuous	Number	+ve
Working_age	Total number of household member aged between 15 - 65	Continuous	Number	
Hectar	Landholding size	Continuous	Hectare	+ve
TLU	Livestock size in TLU	Continuous	Number in TLU	+ve
Fertility	Soil fertility status of farm land	Categorical	1= Fertile 2= Moderately fertile 3= less fertile	+ve
Irrigation	Possessing irrigation activities	Dummy	1= yes, 0 = No	+ve
Extension	Frequency of farmer's contact extension agent	Continuous	Visiting frequency by extension agent	+ve or -ve
Weather info	Access to weather information	Dummy	1=Yes 0=No	+ve
Market Info	Access to market information	Dummy	1=Yes 0=No	+ve
Distance Sell	Distance to the market where sell production	Continuous	Minute	+ve
Distance_ buy	Distance to the market where buy agricultural input	Continuous	minute	+ve/-ve
Institutions	Participating in social institutions	Dummy	1=Yes 0=No	+ve/-ve
Off - farm	Amount of off - farm income	Continuous	Birr	+ve
CSA	Adoption intensity of CSA	Continuous	Intensity score	+ve

Table 6. Variables used for regression of determinants of income and CSA adoption intesnity of household

Variables	**Description**	**Expected signal on income**	**Expected signal on CSA**
Sex	Sex of household head	+ve or –ve	+ve or -ve
Age	Age of Household Head	+ve or –ve	+ve or –ve
Educational status	Educational attainment of household head	+ve	+ve
Fmly_size	Total member of household	+ve	+ve
Working_age	Total number of household member aged between 15 - 65		
Hectare	Landholding size	+ve	+ve
TLU	Livestock size in TLU	+ve	+ve
Fertility	Soil fertility status of farm land	+ve	+ve
Irrigation	Possessing irrigation activities	+ve	+ve
Extension	Frequency of farmer's contact extension agent	+ve or –ve	+ve or -ve
Weather info	Access to weather information	+ve	+ve
Market Info	Access to market information	+ve	+ve
Distance Sell	Distance to the market where sell production	+ve	+ve
Distance_ buy	Distance to the market where buy agricultural input	+ve/-ve	+ve/-ve
Institutions	Participating in social institutions	+ve/-ve	+ve/-ve
Off - farm	Amount of off - farm income	+ve	+ve
CSA	Adoption intensity of CSA	+ve	

4. Result and Discussions

4.1 Descriptive Statistics

The descriptive statistics presented included: the demographic characteristics, socioeconomic characteristics, food security status, income status and CSA adoption intensity of the households presented by using list of tables.

Demographic and socioeconomic Characteristics

The below various tables showed that the household demographic, socio-economic and institutional characteristics at study area. According to the result of survey, majority of the respondents were male headed households 191(93.6%) and 13(6.4%) were female headed households. This result showed the implication of in majority of the country female were more involved on home based activities rather than operating domestic activities like farming work, (Chanie, 2011) cited in Ethiopia the ratio of national average female – headed agricultural households is about 17.6%.

With regard to the educational status of household head 53 (26 %) were illiterate who are could not read and write, the rest households head 151 (74%) had education which could at least read the local language.

The income sources of the respondent household were two according the output generate by STATA and 66.18% from only agricultural activities and 33.82% were from agriculture and non-farm activities earned their 2018/19 production year annual income. Based on this the major occupation of the households was agriculture which showed as the reality on the ground likely the other part of Ethiopia. Of course income diversification had great contribution to increase capacity of households to apply practices those need financial. In the sampled kebeles there were farmers engaged into irrigation activities which economically supported them by gaining high return accordingly 26% of the respondent involved on irrigation agriculture beside rain dependent agriculture activates.

When we try to see the number of livestock including small ruminant and large ruminant of the sampled area households, the mean and standard deviation was 9.32902 and 3.48377 respectively. The average age of sample household heads was 41.53 with standard deviation of

9.99; this showed that the sample households were dominated by relatively middle adulthood farmers who are still within the economically active group. With regard of the average family size were 5.50 persons per household hence when we compare to the national average agricultural household family size holding which was approximately 5.2 people per head the average size of this study area is greater value. This survey tried also to assess the family working age (16 -64) size and in the study area the average working age size was 2.98 with standard deviation of 0.94.

Table 7. Demographic and socioeconomic characteristics descriptive result(Source: Field survey 2020)

Characteristics	**Response**	**Frequency**	**Percentage**
Sex of household head	Male	191	6.37
	Female	13	93.63
Educational status	Illiterate	53	26.0
	Literate	151	74.0
Marital status	Married	184	90.20
	Divorced	9	4.41
	Widowed	11	5.39
	Unit	**Mean**	**Std**
Age	Year	41.53	9.99
Family size	Number of person	5.50	1.41
Farm land size	Hectare	1.82	0.80
Family labor size	Number of person age 14 – 64	2.98	0.94
Total livestock	Number of livestock household posses	25.92	11.35

Institutional characteristics and status of participation

The study result showed us 98.04% of the sample households have agricultural extension contacts. This service user had different numbers contact frequency, accordingly the average contact frequency of the respondents were 3.161 days with standard deviation of 1.10.

The result output indicated that 87.75% of the sampled household took part in on- farmer field day which brought experience sharing chance for farmers, where as 12.25% households did not take a part on thus filed day program which means they didn't get experience or other advantage of participating on field day program.

Regarding to weather related information 55.39% could access of weather information from different source of information, while 44.61% did not have access. Regarding access to market information majority (55.94%) of the household had no market information and the rest (47.06%) did have access. On the side of fertility of soil, 7.35% had fertile farm land, 87.25% moderately fertile farm land and 5.39% less fertile farm land. Majority of farmers were assumed that their farmland was moderately fertile.

About the participating of different institution 91.18% respondents were participating in the different institutions where as 8.82% were not. Chi-square test value shown P=0.045 significant relationship between intensity to adopt practices and participating institutions.

The distance between home and the market where buy input and sell the output mainly their production also one characteristics of the respondent that survey tried to answer based on this the average minute of the distance was 46.45 and 33.86 minute for market where sell production and buy input respectively.

Table 8. Institutional characteristics and status of participation (Source: Own Field survey 2020)

Characteristics	**Response**	**Frequency**	**Percentage**
Participation of institutions	Yes	186	91.18
	No	18	8.81
Access of weather information	Yes	113	55.39
	No	91	44.61
Access of market information	Yes	97	47.55
	No	107	52.45
Fertility level of soil	Fertile	15	7.35
	Moderately fertile	178	87.26
	Less fertile	11	5.39
Characteristics	**Unit**	**Mean**	**Std**
Contact frequency with extension workers	Number of visiting per production season	3.161	1.10
Distance to sell output	Minute	46.45	27.98
Distance to buy input	Minute	33.86	22.67

4.2 Status of food security and income of household in the study area

4.2.1 Food security Status of households in the study area

Although the farmers were engaged into mixed farming system (crop production and livestock rearing), the fundamental source of food supply in the study area was substance crop farming. The most important crops produced in this area were teff, wheat, lentils, chickpea and bean order to various advantages. The majority shared of the sampled households rely on grain produced by them, very small portion of household purchase grain and there no food aid in the area as source of food grain. Food grain balance of the majority of the sampled farmers' fails between 10 -20 quintal of net food grains about 37.3%.

Table 9. Distribution of sampled household by net grain available (Source: Field survey 2020)

Net grain available (Qta)	No of households	% of households
>5	47	23.0
5 – 10	60	29.4
10 – 20	76	37.3
20 – 30	20	9.8
<30	1	0.5
Total	204	

Based on this after computing the balance for each kind of grains using a mathematical equation known as household food balance model which originally adapted by Degefa (1996) which mentioned in chapter three of the research and used by different researchers in this field. Based on the grain type that the community used most of the time the average calories value of each type of food grain (Appendix II) computed per 100 gram.

Table 10. Net food source grains available for the sampled household in the study area (Source: Own computation result based on my survey data 2020)

Food Grain	Net available grain for consumption (Kgs)	Dietary energy Kcal/100gm	Total dietary energy equivalent (Kcal)	Contribution value to total dietary energy supply (%)
Teff	29045	161.20	4,682,054	15.7
Wheat	106822	170.18	18,178,967.96	61.0
Chickpea	21340	227.00	4,844,180	16.2
Lentil	14106	93.50	1,328,91.1	0.6
Bean	15232	127.4	1,940,556.8	6.5
Total	**186545**		**29,778,649.86**	**100**

Based on value of the major end product of each grain conversion process was taken based on EHNRI's food composition table, dietary energy computation from all kind of net food grains for all sample households generally categorized as below table, categorization value adopted from Degefa (2015).

The result of survey reported from household food balance model, the total amount of energy available for the households was 29,778,649.86kcal with 1369.53kcal average daily per capita amount; regarding the contribution value to total dietary energy supply wheat, take the major share (61.05), chickpea 16.2%) and teff (15.7%) takes the second and third position.

Table 11. Distribution of dietary energy available in Kcal for the sampled households (Source: Own computation result based on my survey data 2020)

Food security status category	Level of daily per capita dietary Kcal available	Number of households falling in the respective category	Percent of household falling in the respective category
Food secure	>=2100	42	20.6
Mildly food insecure	>=1750 - < 2100	41	20.1
Moderately good insecure	>=1500 - < 1750	20	9.8
Highly food insecure	>= 1000 - < 1500	31	15.2
Severely food insecure	<1000	70	34.3
Total		**204**	**100**
Min (kcal)	**Max (kcal)**	**Mean (kcal)**	**Std (kcal)**
107.41	3196.10	1369.5378	788.70822

Concern on the distribution of available dietary energy of the household, the survey reported that the minimum Kcal was 17.41 whereas the maximum was 3196.10 kcal this implies there was vast gap between the regarding the amount if dietary obtained. This result lined with Degefa (2015), the gap between minimum and maximum value of the available energy was wide. There were households that obtained 194 kcal of available dietary energy whereas others, indeed few numbers obtained up to 2557kcal. Amrtyan (1981) cited Napoli (2010/2011) reflect the idea support this finding regard to distribution of dietary energy where food is in surplus production there may be households or individuals at risk of food shortage.

The study attempted to measure food security status of the households based on the above categorized into different group based on their daily per capita dietary energy level, accordingly when we compare with the minimum daily per capita dietary energy recommended for healthy and active adult individuals, which is 2100kcal, only 20.6% fulfill the minimum daily per capita calories, from the total food insecure group of the sampled households, 20.1% fell in mildly, 9.8% moderately, 15.2% highly and 34.3% severely food insecurity categories.

The study area was thought as surplus food producer and was assumed to be highly food secure; however, unlike as it is observed from the result majority of the sampled households making up to 34.3% were found to be food insecure, which need further investigation but generally it is possible to say 79.4% of the study area households were food insecure.

4.2.2 Income Status of households in the study area

The household survey witnessed that, all the sampled households in the study area engaged in agricultural activities, implies all of them were involved in crop production and livestock production. This lined with national estimate of the country, where more than 80% of the population is engaged in agriculture, Central Statistical Agency of Ethiopia (2010). Farmers in the study area mainly produced cereals although producing vegetable by using irrigation 26.5 % of total sampled was also one of the farming activities that household engaged. Poultry rearing, fattening sheep and large ruminant were the major livestock production which was the major income source next to crop production and based on the below summary table in addition to agricultural activities, some households (33,8%) were also engage into non-farm activities refers to handicraft, petty works, trade and employment and can generate income.

Table 12. Income source of sampled households (Source: Own computation result based on my survey data 2020)

Income source of household			
	Frequency	**Percent**	**Cumulative percent**
Agriculture	135	66.2	66.2
Agriculture and off - farm	69	33.8	100
Total	204		

Table 13. Irrigation adoption status of sampled households (Source: Own computation result based on my survey data 2020)

Irrigation adoption			
	Frequency	**Percent**	**Cumulative percent**
Yes	54	26.5	26.5
No	150	73.5	100
Total	204		

Sampled household income is measured by economic model adopted from a joint guidance document of the committee on sustainable assessment (COSA), the ISEAL alliance and the sustainable food lab (2016) accordingly; The below summarized table describe the status of total net household income of sampled household, which was in range between 21,200 – 272,500 ETB. The average income earned according the model was found to be ETB 103,483 (US$ 3,449.43) in this study year of production.

Variable	**Obs**	**Mean**	**Std.Dev**	**Min**	**Max**
Total net household income(birr)	204	103483.9	57175.21	21200	272500

4.3 Adoption intensity of climate smart crop production practices

Type of climate smart agriculture practices adopt by household varied from household to household, according to the survey output some of the household applied to the whole practices listed on the tool(questionnaire) whereas some applied(adopted) half the listed practices, in response to these adverse impacts based on their perception that climate variability occurred during the last 30(after EPRDF took power) and also they believed that climate variability had great impact on crop production as well as other agriculture activities.

At country level government has initiate different program to enhance this climate smart agriculture practices, for instance agricultural growth program (AGP), sustainable land management (SLM) are promoting programs at country level.

The survey output showed that the whole respondent farmers adopted at least seven of the practices listed on the questionnaires and this practice listed down based on FAO (2016) reports that present common CSA practice in Ethiopia. result show that the widely adopted practices are reducing tillage (99.5%), crop diversification practices which include popularization of new crops and crop varieties, pest resistance, high yielding, tolerant to drought, short season takes 97.5% and crop rotation (90.2%) and the less adopted are tree based conservation agriculture(15.7%), efficient water utilization (31.4), year rounding (50%), compost and manure management (65.7%) , natural regeneration(70.1%), practicing traditional as improved one (72.1%), crop residue management (74%) and efficient fertilizer application were the intermediary adopted climate smart crop production practices.

Table 14. Adaptation intensity of climate smart agriculture practices of study area(Source: Own field survey 2020)

	Frequency				
Adoption Type	**Yes**	**Percent**	**No**	**Percent**	**cumulative**
Reducing tillage	202	99.5	2	1.0	100
Crop residue management	151	74	53	26	100
Crop rotation	184	90.2	20	9.8	100
Compost and manure management	134	65.7	70	34.3	100
Efficient fertilizer application	163	79.9	41	20.1	100
Year round cropping	102	50	102	50	100
Efficient water utilization	64	31.4	140	68.6	100
Tree based conservation agriculture	32	15.7	172	84.3	100
Practicing traditional practice as improved one	147	72.1	57	27.9	100
Natural regeneration	143	70.1	61	29.9	100
Popularization of new crops	198	97.1	6	2.9	100
Popularization of crop varieties	200	98.0	4	2.0	100
Pest resistance	200	98.0	4	2.0	100
Highly yielding	200	98.0	4	2.0	100
Tolerant to drought	198	97.1	6	2.9	100
Short season	197	97	7	3.0	100

As mentioned above all sampled households adopted at least seven climates smart crop production practices for teff and wheat production during 2018/19 cropping season which is good experience adopting multi practices rather than sticking on little practices and this has to be scaled up. The study grouped the respondents based on the adoption intensity derived from calculating adoption intensity scores level and multiple linear regression (MLR) analysis.

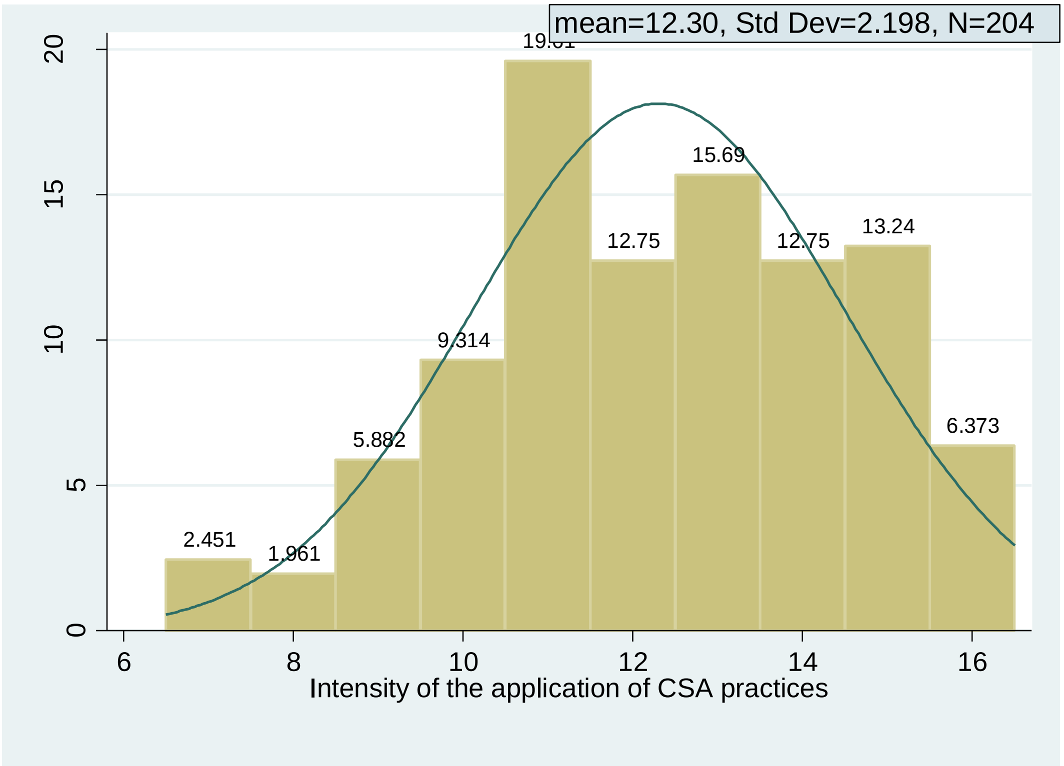


Figure 4. CSA adaptation intensity distribution at study area (Source: Field survey 2020)

The result displayed on the above histogram indicates the minimum adopted practices were seven and the maximum number of practices adopted was 16 which mean the full listed on the tool. The minimum adopters under lower score the majority were in medium level. The mean adoption intensity score was 12.30 and standard deviation was 2.198 which was there good and encouraging adoption practices which should be scaled up to other area.

4.4. Econometric results and discussion

This analysis part of the study mainly focuses on the analysis of major factors that determine food security, income and CSA practices adoption intensity level of the sampled of the farm household in Gimbichu woreda. Thus, in this part of the study, the analysis focusing on the research questions was provided; the first part of the econometric analysis was about assessing the adoption intensity of CSA on food security and income of smallholder households. In the second part focuses on identifying the factors that affect the adoption intensity of CSA practices.

Multiple linear regression models were applied to estimate the effect of CSA practices on food security, income of household and again to estimate factors affect adoption intensity of farmers' choice of adopting CSA practices.

A binary discrete choice regression model (Tobit or Multiple linear regression models) can be used for estimation. In this study, therefore, both Tobit and multiple linear regression models were compared for all above mentioned estimation. Given the two models, the one with the smaller Akaike information criterion (AIC) and the Bayesian information criterion (BIC) fits the data better than the one with smaller AIC and BIC Stata Corp (2013). Accordingly, multiple linear regressions were preferred over Tobit model in estimating the effect of CSA practices on food security and income and tin estimating the factor affecting the adoption Intensity.

Table 15: AIC and BIC test (Source: Own computation result based on my survey data 2020)

Model	**Obs**	**Log likelihood for the model**	**df**	**AIC**	**BIC**
Tobit	204	-368.6314	17	771.2627	827.6708
MLR	204	-368.6314	16	769.2627	822.3526
Factor of CSA Adoption intensity estimates					
Model	**Obs**	**Log likelihood for the model**	**df**	**AIC**	**BIC**
Tobit	204	-2157.636	17	4349.271	4405.679
MLR	204	-2028.616	18	4093.232	4152.958
Effect of CSA on Food security estimates					
Model	**Obs**	**Log likelihood for the model**	**df**	**AIC**	**BIC**
Tobit	204	-161.4358	18	358.8717	418.5978
MLR	204	-161.4358	17	356.8717	413.2797
Effect of CSA on Income estimates					

4.4.1 Model Diagnosis Test

The model tested for the appearance of multicollinearity, hetrosckedasticity and normality problems. Linearity problem was checked by using link test; accordingly, hatsq values for three models are insignificance (Appendix IV). Linear regression analysis requires all variables to be multivariate normal; to check this assumption checked by normal probability plot. Hence, the data was normally distributed over the residual line (Appendix V).

The problem of multicollinearity among the independent variable was tested using variance inflection factor (VIF) for continuous variables and contingency coefficient for dummy variables separately. Based on this, there was no multicollinearity problems detect in all cases for all model estimations since the value of VIF all continuous variables was less than 10 and for dummy variable p value greater than 1% (Appendix VI). The hetrosckedasticity problem was also checked by creating a residual plot. As a result, it was not found any hetrosckedasticity problem during the estimation of factor determinants (Appendix VII).

For all MLR model output, only the variables that were statistically significant at less than to 5% probability level are interpreted and discussed.

4.4.2 Effect of Adoption intensity of CSA practices on food security of households

To be more productive and to improve food security status, farmers in the study area developed their own coping mechanism. Study conducted by (Degeffa 2015) show that changing cropping pattern, which implies growing drought tolerant crops were adopted to increase crop production, which could improve food availability. Sampled households had different level of intensity of using climate smart crop production practices; thus, the level effect is the difference in food security status. Due to the usage intensity of the practices, the larger intensity all users were more food secured compared with the less adopter.

The Below table from Stata output presents, the regression analysis of CSA adoption effect and other predicted variables in terms of value getting from household food balance model. Accordingly, age of household head, family size, TLU, distance to buy input, off-farm income, possessing irrigation and CSA adoption intensity of the household have statistically significant effect on the food security of households at 5% level of significance since their p – value is smaller than 0.005, whereas the rest explanatory variables are insignificant since their p – value are greater than 0.005. Hence, the significant variables can be interpreted as follows.

Table 16. Regression output for food security (Source: Own computation result based on my survey data 2020)

Food_ security	**Coef.**	**P>t**
Sex	.0522822	0.805
Age	.0084911	0.019
edu_level	-.146247	0.194
Family_size	-.1473084	0.001
Family labor size	.0082853	0.869
Hectar	.0458484	0.606
TLU	.0423488	0.028
Contact_frequency	.0653591	0.245
Instituation	.0264094	0.856
Dist_buy_input	-.0136149	0.000
Dist_sell_output	.0034448	0.245
Market_info	.0152227	0.885
Wheather_info	.0210253	0.917
Fertlity	.1755876	0.244
Possess_Irrigation	.3149392	0.030
Off_farm_Income	.3120486	0.019
CSAIntensity	.1259517	0.036
_cons	7.743363	0.000

Based on the above analysis the significant model that can be fitted using the response variable; food security vs seven indicator variables that have collectively significant effect on the response variable could have the form like:-

Y(Food security)= 7.74 + 0.084age – 0.147family size + 0.0423TLU – 0.013distance to buy input + *0.312off - farm income + 0.31irrigation adoption + 0.125CSA adoption intensity.

The average food security is 7.74 by setting all the predictors to zero. Age of household head had a significant effect on household food security status since the p – value = 0.019. Furthermore, the average value of household food security increases by 0.084 for unit increases of the age of household head. The likely reason for this farmer heads doing their agricultural activity with judgment and effectively based on experienced gained through time. Beyene and Muche, (2010) find age of the positive and significant relationship with food security, the possible explanation they put is, young people spend much time in town and prefer urban life than the rural for a number of reasons. This explanation might workable on the scenario of this study area. Young household head more interested on spending their time on nearby town like Bishoftu and Chafe Donsa and also interested doing factory and daily work on construction rather than farming.

Household family size had also a significant effect on household food security status at p – value 0.001 which is less than the α-level. Moreover, the average value of household food security status decreases by 0.147 for unit increase of family size within household; this is theoretical supported as per family size increased consumption amount also increased during this time food shortage would be happen within household which exposed them for food insecurity. This finding similar with Demeke(2011), which reported an increase in the family size results in an increase in the probability of food insecurity by 36.25 percent.

Total livestock household possession in TLU has a positive effect household food security. Hence, the average values of food security status of household increased by 0.0423 for unit increase of livestock number. Livestock possession has manifold advantages for rural household; livestock serve as production asset (mainly oxen); at the same time, it has high contribution for food ensuring food security of household since farmers' used dairy product for consumption. Moreover, people require a range of productive resource/assets to achieve a positive livelihood outcomes, particularly sustainable livelihood and food security (Meskerem and Degefaw, 2015).

Distance to buy input also has a significant effect on farmers' food security status, but their association is negative. This implied that the average value of food security decreases by 0.013 for a unit increment of minute to reach market center where they buy agricultural inputs. Similar finding with (Morodaet.al., 2018) distance to input and outputs markets was found that a strong negative influence on the food security situation of the households; i.e. a unit increase in distance from input and output markets increase the probability of being food insecure with 14 percent. It could be therefore, concluded from this finding to access diversify food item as well as to get easily non – agricultural food commodities market center infrastructure should be expanded.

As explained on descriptive part, some of sampled households are engaged into non – farm activities. The result of regression also showed income earned from non – farm activities effect household food status positively which has been acknowledged; the average value of food security status of household increase by 0.34 for one birr increase their income. Demeke*et, al.*, (2011) have reported a positive and significant effect of off - farm activities in rural areas.

Irrigation effect food status of household positively; the average value of food security of household increase by 0.31 for status of adoption changed from non-adopter to adopter. The finding of this study showed clearly that the contribution of irrigation to household food security as adopting irrigation helped to rise in crop yield and decreased of food prices, which could contribute for availability of surplus food commodities on the market. To combat food problem happened due to crop failed specifically irrigation based agriculture and agricultural development in general would be crucial. Desta (2004).cited on Derbew (2009)

CSA adoption intensity effect positively, regression result on table 16 showed that the average value of food security increase by 0.125 for unit increment of adopting component of CSA practices. The core aim of climate smart agriculture practices were ensuring food security and improving wellbeing of households; of course, the study result also revealed this assumption. The positive impact of adopting CSA has been explained in different studies. For instance Wekesa *et al.,* (2018) for Kenya have reported for larger CSA practices package all user were more food secure compared to their counterparts who did not use CSAs in the actual scenarios.

ANOVA for food security

Table 17: Anova for Food security (Source: Own computation result based on my survey data 2020)

Analysis of Variance					
Sources	SS	Df	MS	F	Prob> F.
Between groups	13.7169024	9	1.52410027	1.71	0.034
Within groups	172.871333	194	.891089345		

The Above table output presents Analysis of variance (ANOVA) for adoption effect on group of food security status group in terms of value getting from household food balance model. In these results, the null hypothesis states that the mean food securities of four different groups are equal. In this result, the null hypothesis states that the mean food securities of four different groups are equal. Since the p-value is 0.034, which is less than the significance level of o.o5, we can reject the null hypothesis. Generally, depending on the hypothesis we can conclude that, adoption effect on food security status group in terms of value getting from household food has a significant effect or difference.

4.4.3 Effect of Adoption intensity of CSA practices on Income of households

Starting by presenting the result of the regression analysis that would provide reliable estimate of impact when there is limited selection bias due to unobserved factors, the below regression result showed the listed Climate smart crop production practices has a significant impact on household income; in addition to that size of farm land, minute takes to reach market center where sell the production from homestead, accessing weather information, adopting irrigation, producing and off - farm income had effect income of sampled household, where average income value of households was 10.56 by setting all the factor zero .

Table 18. Regression for income (Source: Own computation result based on my survey data 2020)

Income	**Coef.**	**P>t**
Sex	-.0360308	0.831
Age	.0072841	0.159
edu_level	-.0372585	0.677
Family_size	-.0255814	0.453
Family labor size	-.0496077	0.217
Hectar	.1519767	0.033
TLU	-.0052252	0.731
Extension	-.0445192	0.320
Instituation	-.1212388	0.298
Dist_buy_input	-.0006704	0.813
Dist_sell_output	-.0062778	0.008
Market_info	.0986249	0.023
Wheather_info	-.4218649	0.000
Fertlity	-.1927199	0.109
Possess_Irrigation	.1546981	0.018
Off-farm_Income	.2541996	0.015
CSAIntensity	.1335654	0.000
_cons	10.56977	0.000

Based on the analysis, response variable could have the following form:-

Y(Income)= 10.56 + 0.151hectar – 0.006distance to sell production – 421weather info + 0.154 adopting irrigation + 0.254off - farm income + 0.133CSA adoption intensity.

Farmland size measured in hectare effect income of household positively. Furthermore, the income of household increased by 0.1519 for a unit increase of farmland size. This could mean that when farmers' possess more cultivable land there is probability to increase their productivity as well they could produce variety of crop those have high market value, which could open good opportunity to improve their income status. In the study area, household owned large size of farmland cultivate different crop type in addition to teff and wheat like chickpea, lentils which had high market price, In line with a study by Teshome and Edriss (2013) Time take to reach market center where household sell their production effect income negatively. The result showed decreases 0.006 for a minute increase of the distance. It is obvious that distance to market lowers the income if farmers unable to access market at nearby they devoted much time there this directly affect time should use for farming activities spending their time on unproductive business (journey). Even though if the market center far from the residence of farmers they would not encourage involve into off-farm activities which help them to diversify their source income as well as help to increase income of the households.

Accessing weather information has also a significant effect on income of household at p – value = 0.000 which was less than α-level. But their association was negative. This implied the average value of income of household decreases by 0.4218 for having access of weather information. Having consistent weather information was essential to produce more production and to protect their source of income from climate related hazard. However, the result showed negative association. Farmers' in the study area mostly had access to weather information from development agent though the negative association result could be due to the ineffectiveness of the source of weather information and may be farmers' spend their time for generating income on accessing weather information.

Adopting irrigation had also positive effect on household income in the study area since p = value 0.018, which is the average income value of household increased by 0.154 for adopting irrigation. The results clearly showed the fact that irrigation had great opportunity to improve farmland productivity and produce high market value production. In the study area, some household engaged into irrigation activities and produce different vegetable those are high market price like onion, tomato, potato and garlic. Finding of Abraham *et, al.,* 2015 has also support this result that small scale irrigation has positive and significant impact on income of farm household.

Generating off-farm incomes had also a significant effect on average value of income (p=0.015). It therefore, implied that the average value of income increases by 0.254 for a birr increment of off - farm income. However, agriculture is major source of income for farmers'; off-farm activities also had positive contribution for improvement of status of income of the household.

Generally, it could be concluded that diversifying income source enabled the farmers to generate more income which, could help them to improve their wellbeing.

Adoption intensity of CSA practices on crop production has positive and significant impact on average income value with p=0.000 and significant at5% significance level, implies per household adopt one additional practice average value of income increase by 0.133. Climate smart agricultural practices have the potential to reverse this trend because of its triple potential benefits of improved productivity and high income, reduction or removal of greenhouse gases and improved household food security (Wekesa*et.al.,* 2018). In the same token, in the study area farmers adopt excessive number of CSA practice package, which could produce high yields and could contribute for improvement of income status.

4.4.4. Factor Affecting Adoption intensity of CSA practices

The result in the table (18) showed that the relationship between Climate smart crop production and the factor affect the intensity of the practices. The model demonstrated the coefficient of determination (R^2) showed that the model explained 45% of variation in climate smart crop production adoption, which implies that for household adoption intensity level vary from few number of practice adopter to numbers of practiced households, which could be realistic on scale of operation among wheat and teff producer households. Similarly with the above argument, it is known that as sample size increases, the difference between the R^2 and adjusted R^2 become less.

The result from the regression showed that sex of household head, age of household head, number of family member in age between 15 – 65, size of farm land does household had contact frequency with extension service provider experts; participation within social institutions, access to weather information and participation on farmers field day had statistically significant on the intensity of climate smart crop production adoption of farmers.

Table 19: Multiple linear regression model of factor affecting CSA adoption intensity (Source: Own computation result based on my survey data 2020)

CSAIntensity	Coef.	P>t
Sex	.9472203	0.034
Age	.0246315	0.072
edu_level	-.3792504	0.110
Family_size	.1765921	0.050
Family labor size	-.5002558	0.000
Hectar	.5068512	0.007
TLU	.0127816	0.753
Extension	.7472577	0.000
Instituation	.6415486	0.037
Dist_buy_input	-.0251681	0.001
Dist_sell_output	-.0039562	0.528
Market_info	.0685042	0.758
Wheather_info	.8264819	0.003
Fertlity	.2413083	0.449
Possess_Irrigation	1.222632	0.000
Off-farm_Income	.0000488	0.000
_cons	5.727212	0.000

Based on the above analysis (table 18) report, response variable could have the following form:-

Y(CSA Intensity)= 5.72 + 0.94sex – 0.5between + 0.5hectare + 0.7extension + 0.64instituation - 0.02distance + 0.82weather info + 1.2possess irrigation + .0000488off_farm income

Sex of the household head is positively related to adoption and significant at 5% significance level (p=0.034). The result indicated that as sex of household head changes from female to male the probability of becoming highly adopting by 0.947, as hypothesized male headed households had better opportunity to practices adaptation strategies. The result similar with Mulatu & Negash (2011) overall male-headed household has greater preferences for soil conservation and irrigation adaptation measures to climate change than female headed households.

The household family size had negative and significant relationship with intensity of adoption at 5% significance level (p=0.000), as one unit increment family size the probability of being adopter decrease by 0.176. The reason for negative association appear due to if there are sufficient opportunity for off-farm labor and off - farm work opportunity, which they can gain more return than farming. It might be assumed that this was due to the fact that the study area is closed for big city, Bishoftu and sendafa where there is factories that have high work opportunity.

According to the descriptive result all of the sampled household access farm land, in the MLR model analysis size of farm land become significant and has positive relationship with intensity of adoption of the practices (p=0.007) at 5% significance level. This implied as farm land size increase by one unit (hectar) intensity of adopting CSA score of farmers increases by 0.506. It could be interpreted that landholding size is very important; having land is a fundamental natural resource to run farming activities highly. The result supported by (henry 2011) that proves that farm size has positively and significantly increased the likelihood of adoption of climate change practices. Furthermore, large farm sizes provide an opportunity for diversification of their crop and livestock enterprises, and it can help to distribute risks associated with unpredictable weather (Abreham Belay et al., 2017).

According to the survey report, all household could access extension service even though there was difference on frequency of contacting; the finding of this study was also similar with various studies which was statistical significant (p=0.000), at 5% level of significance. There is positive relationship with intensity of adoption as for one day contact of DA, increase CSA adoption intensity value of farmers by 0.74. The result of study in line with, the presence of a strong positive relationship between accesses to information through extension services delivery increases the farmer's likelihood of adopting climate changes (Maddison 2006; Deressa et al., 2009).

Another important factor that influenced the intensity of climate smart crop production practices was being member of institution, for instance farmers' cooperative, edir and ekub. The result of study also reveals the same, it has positive relationship with adoption intensity and significance (p=0.0.037) and the result indicate that being member of social institutions of household head changes from non - member to member, CSA adoption intensity score increase by 0.64. This is similar with the findings of (Tessema *et al.,* 2013) which reported social network can facilitate cooperation to overcome collective action dilemmas and helps those farmers that participate in different social activities to have better information to adopt improved practices when compared with non-participants.

Minute takes from home to market where the household buy agricultural input measured by minute and the result of MLR model shows that there is negative relationship between intensity of adoption at the same time it's significant at p=0.001. Again the results showed that as increments of minute by unit adoption intensity score decrease by 0.25.Maddison (2006) the proximity to such market is an important factor for adaptation since among other it is the better social capital and the place where farmers can exchange information with other farmers.

Regarding to access of weather information the respondent reported majority of them can access through different means. The MLR model analysis result revealed the existence of significant statistical difference between the smallholder farmers adopting intensity (p=0.003) and has positive relationship with dependent variable, the average adoption intensity score increase by 0.82 for status of household change to accessing weather information. There is no doubt on the importance of weather information that affect adaptation options the result of survey also prove that a farmer who had better access to weather information made better informed adaptation decision. The result also line with result of (Mulatu & Negash 2011) access to climate forecast information also increases the likelihoods of preferring multiple cropping as the most preferred strategy by 6.2% and changing planting dates by 8.4%.

Some part of the study area households were engaged into irrigation production which is explained above section although irrigation adoption status of households effect CSA adoption intensity; furthermore, average value of intensity score increase by 1.22 as farmers' participate on irrigation production. As discussed above earlier adoption of irrigation farming practices has influence household income, implies when the economic capacity of farmers' strengthen the probability of adopting CSA practice widely especially those are required financial cost,

Financial resource is essential factors to highly adopt CSA practices and in the study area some of the sampled households gain off–farm income. Off–farm income has also a significant effect on farmers' adoption intensity of climate smart crop production practices at p – value=0.000 which is than the α-level. Additionally, the average value of farmers' adoption intensity score of climate smart crop production practices increases by 0.0000488 for a unit (birr) increment of off

- farm income. Contrary to this, Tewodros (2018) reported that farm income than agricultural activities (Off-farm income) is the most influential factor that affects farmers' decision to adopt mulching, household who were engaged in off-farm activities adopt mulching practices 3.333 times greater than those who were not engaged in the off-farm activities.

5. Conclusion and Recommendations

5.1. Conclusion

The relationship between climate smart crop production practices and food security and income of smallholder households is complicated and there is little empirical evidence in Ethiopia. Since agriculture plays an important role in improving household food security and income of the smallholder households, climate smart agriculture practices are one of the options in this regard. These study analyses the status of adoption of CSA at study area, factors which affect the adoption of CSA were also investigated. Additionally effect from adoption intensity of climate smart agriculture practices on crop production in the Gimbichu woreda, Ethiopia are examined.

Systematic random sampling method was used to select respondents and study area. Data were collected from farmers' predominantly produce wheat and teff from three villages in Gimbichu woreda. To assess the adoption status of the study area farmers' fundamentally were descriptive analysis were by using frequency and descriptive table. Multiple linear regressions were used to estimate the causal effect of climate smart agriculture practices on household food security and income. Similarly, multiple linear regression analysis was used to explore the factors that determine adoption intensity of households on crop production.

In order to answer the first research question, what type of the CSA practices are highly adopted by smallholder producers of Teff and wheat in the study area the result could be conclude as follows. Various combined climate smart crop production practices were used by farmers' in response to rehabilitated crop production. All sampled households have adopted at least seven CSA practices. These are reducing tillage, crop residue management, crop rotation, compost and manure management, efficient fertilizer application, efficient water utilization, tree based conservation, crop diversification. Reducing tillage, crop diversification (popularization of new crops and crop varieties, pest resistance, high yielding, tolerant to drought, short season) and crop rotation are the first three ranked adoption practices; whereas tree based conservation agriculture and efficient water utilization are less adopter with 32 and 64 households respectively.

The second analysis focused on investigated the major factors affecting household adoption intensity level of CSA. Output show that Climate smart crop production practices contributes to household food security and income status positively. There were significant differences of farmers' adoption intensity level regard to independent variables such as sex of household head, age of household age, farmland size, total livestock possess, family size age between 16 – 64, distance between market were buy input and homestead, contact frequency with extension service providers, being member of social institutions, weather information and participating on farmers field days. Majority factors except distance between homestead and family size age between 16 -64 the rest explanatory variables have positive and significant effect on adoption intensity level of Climate smart crop production practices. Therefore it could be conclude that teff and wheat producers having good social networking, experienced in farming practice, access large size of land, having extension contact frequently with agriculture expert, have weather information and male household headed are more likely have high adoption level of climate smart crop production practices.

Thirdly the research attempt to answer effect of climate smart agriculture crop production practices of CSA' adoption intensity of farmers' on crop production for household food security and income. Indeed, multiple linear regression model result shows that as adoption practices of farmer's increases it's has positive effect on household food security and income. The estimates for the average income within period of the production season income earned from crop production and livestock raring ranges from 21205 to 336607 ETB. This result indicates that in highly adoption intensity of CSA significantly improves incomes in comparison with low adopter farmers'. Regarding food security status of sampled households ranges from 107.4kcal – 3196.1kcal. When we compare this value with standard of 2100kcal there were very low kcal per day at same time there were household that afford surplus food per day.

5.2. Recommendations

To promote and expand climate smart crop production practices sustainably and widely the following policy recommendations are given:

- Different type of climate smart agriculture practices are implemented by farmers', so these effective practices which are suited to the agro-ecology characteristics of area should apply comprehensively. For effective implementation of practices, necessary capacity building, technical support and financial support must be provided from every stakeholder.
- Having frequent contact with extension service provider positively affect the adoption level of farmers', implies to increase the awareness of farmers' strong extension service is important. Building capacity of extension service provider (development agent) regarding CSA practices can help to easily disseminate the required knowledge to reach mass farmers'.
- Establishing farmers' cooperative at nearest place to provide easily agricultural input for the seek of saving production time as well to get inputs timely, although distance between homestead and market where buy input negatively affect household adoption level of practices.

This study concentrated on one aspect of climate smart agriculture practices on crop production. However there are many aspects of climate smart agriculture that need further research with wider scope. It is important to extend its potential effect on other components of livelihood, environmental actions and technological adoption of households. In addition, since the focus of this study is crop production, it is important to extend this study on different agriculture practices especially this area has rich naturally endowment to produce export oriented agricultural like oil grain. This will provide a broader view on the value of climate smart agriculture practices and suggests better ways to increase the benefits of farmers'.

Reference

AbbysiniaMushunje, Abenetbelete and Gavin Fraser, (2003). Technical Efficiency Of Resettlement Farmers Of Zimbabwe. Contributed Paper Presented At The 41th Annual Conference of The Agricultural Economic Association of South Africa (AEASA), October 2-3, 2003, Pretoria, South Africa.

Abraham GebrehiwotYihdego, Addis Aderagebru, Mesfin Tilahun Gelaye, (2015). The Impact of Small – Scale Irrigation on Income of Rural Farm Households: Evidence from Ahferom Woreda in Tigray, Ethiopia. International Journal of Business and Economics Research.

Abrham Belay, John W. Recha, Teshale Woldeamanuel and John F. Morton, (2017).Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia.

African Center for Economic Transformation, (2014).African Transformation report. Growth with depth. Center for Global Development.

AdugnaLemi. (2009). Determinants of Income Diversification in Rural Ethiopia: Evidence From Panel Data

Ajayi OC, Place F, Kwesiga F, and Mafongoya P, (2007). Impacts of improved tree fallow technology in Zambia.

Alejandro Nin-Pratt, Michael Johnson, Eduardo Magalhaes, Liangzhi You, Xinhen Diao and Jordan Chamberlin (2011). Yield Gaps and Potential Agricultural Groth in West and central Africa.

Alem-meta Assefa Agidew and K.N. Singh. (2018). Determinants of food insecurity in the rural farm households in South Wollo Zone of Ethiopia: the case of the Teleyayen sub watershed.

BekeluTeshome and Abdi – Khalil Edriss, (2013).Determinants and Patterns of Income Diversification among Smallholder Farmers in Akaki District, Ethiopia.

Below, T., Artner, A., Siebert, R.,& Sieber, S.(2010). Micro-level Practice to Adapt to Climate Change for African Small-scale Farmers. Washington, D.C.. International Food Policy Research Institute (IFPRI).

Berg, M. V. D. and G. E. Kumbi (2006), Poverty and the Rural Non-Farm Economy in Oromia Ethiopia. International Association of Agriculture Economists Conference, Gold Coast Australia

BikilaTesfakebeda, Temesgen Olani Abdisa and Abera Jaleta Berkessa, (2019). Review on The Expected Role of Climate Smart

Botha, J. J., Anderson, J. J., & Van Staden, P. P. (2015). Rainwater harvesting and conservation tillage increase maize yields in South Africa.

Bournaris et al., 2016;Keshavarz&Karami, 2014).

Bright masakhaWekesa, Oscar IngasiaAyuya and job Kibiwotlagar. (2018). Effect of climate-smart agricultural practices on household food security in smallholder production systems: micro-level evidence from Kenya

CARIAA working paper#8, Daniella Echevettia and AnikaTerton, (2016). Review of current and planned Adaptation Action in Ethiopia.

Central Statistical Agency (CSA) (2007) Population and Housing Census of Ethiopia: Central Statistical Agency, Addis Ababa, Ethiopia.

DegefaTolossa (1996). Belg Crop Production as a Strategy of Households' Food Security: A Comparative Study of Belg Grower and Non Belg Grower Farmers in Munessa woreda, Arsi Region. M.A Thesis. Addis Ababa University, Addis Ababa.

Degefu Kebede Bayecha, (2013). Economic Impacts of Climate change on the teff production in Lume and Gimbichu Districts of Central Ethiopia. a dissertation submitted in partial fulfillment of the requirements for the degree of master of science in agricultural and applied economics of Sokoine university of agriculture. Morogoro, Tanzania.

Demissie GelasheFeyisa, (2018). Smallholder Farmers 'Adoption of Climate Smart Cattle. Production practices: status and determinants in Waliso woreda, southwest Shoa zone, Oromia national regional state, Ethiopia.

Derbewkefiyalew Abegaz, (2009). Small-scale irrigation and rural livelihood diversification in north-wastern Ethiopia: a case of Alawuha irrigation scheme in Gubalafto woreda, North Wollo.

Temesgen.Deressa, Rashid MH. (2009). Economic impact of climate change on crop production in Ethiopia: Evidence from cross-section measures.

Temesgen.Deressa, R. M. Hassan, C. Ringler, Tekie Alemu, and Mahmud Yesuf, (2008). Analysis of the Determinants of Farmers' Choice of Adaptation Methods and Perceptions of Climate Change in the Nile Basin of Ethiopia, IFPRI Discussion Paper No. 798 (Washington, DC: International Food Policy Research Institute)

Emily Shipman (Sustainable Food Lab), Gabriela Soto (COSA) Jessica Mullan (COSA), Marta Maireles González (ISEAL Alliance) and Stephanie Daniels (Sustainable Food Lab), (2016). Measuring smallholder incomes; towards better alignment and reporting of farm economic metrics, A joint guidance document of the committee on sustainability assessment (COSA), the ISEAL Alliance and the sustainable Food lab.

Emmanuel A. Ojoko , James A. Akinwunmi, Sulaiman A. Yususf and Ombowale A. Omi. (2017). Factors Influencing the Level of Use of Climate-Smart Agricultural Practices (CSAPs) in Sokoto state, Nigeria

EngdaworkAssefa, (2015). Characterization and classification of the major agricultural soils in CASCAPE intervention woredas in the central highlands of Oromia Region, Ethiopia.

FAO (2008).Climate change adaptation and mitigation in the food and agricultural sector. FAO, Rome

FAO (2010). Climate-smart" agriculture: policies, practices and financing for food security, adaptation and mitigation, FAO, Rome

FAO (2010).The state of Food Insecurity in the World Addressing Food Insecurity in Protracted Crises, Rome.

FAO (2013).Climate – Smart Agriculture Sourcebook. FAO, Rome

FAO (2013).Multiple dimensions of food security. FAO, Rome

FAO (2015). The economic lives of smallholder farmers, An analysis based on household data from nine countries. FAO, Rome

FAO (2016).Ethiopian Climate Smart Agriculture Scoping Study.By Jirata, M., Grey. S. and Kilawe. E. Addis Ababa, Ethiopia

FAO (2017).Climate – Smart Agriculture Sourcebook. Summary second edition.

FAO 2010 Food and Agriculture Organization (FAO-Adapt) (2010) Framework Program on Climate Change Adaptation. FAO, Rome.

FAO, (2010). Climate Smart Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation. FAO, Rome.

FAO, (2015).The economic lives of smallholder farmers, Rome, FAO, Rome.

FAO, (2018).Small Family Farms Country Factsheet. FAO, Rome

FAO, IFAD, UNICEF, WFP and WHO, (2018).The State of Food Security and Nutrition in the World 2018.Building climate resilience for food security and nutrition. Rome, FAO,

Federal Democratic Republic of Ethiopia, Growth and Transformation Plan II (GTP II) (2015/16 – 2019/20); Volume I: National planning Commission May, 2016 Addis Ababa

Fekadu Beyene and Mequanenet Muche, (2010). Determinants of Food Security among Rural Households of Central Ethiopia: An Empirical Analysis.

Bekabil Fufa, Rashid and M. Hassan. 2003. Stochastic maize production technology and production

risk analysis in Dadar district, East Ethiopia. G. Ramakrisha and Assefa Demeke. (2002). An Empirical Analysis of Food Insecurity in Ethiopia: The Case of North Wello.

Gerald C.Nelson, Mark W. Rosegrant, Jawoo Koo, Richard Robertson, Timothy Sulser, (2009). Climate change impact on Agriculture and costs of Adaptation.

GiacomoBranca, Nancy McCarthy, Leslie Lipper and Maria Christina Jolejole, (2011). Climate Smart Agriculture: A Synthesis of Empirical Evidence of Food Security and Mitigation Benefits from Improved Cropland Management.

Giacomo Branca, Nancy McCarthy, Lesliw Lipper and Maria Christina Jolejole, (2011). Climate Smart Agriculture: A synthesis of Empirical Evidence of Food Security and Mitigation Benefits From Improved Cropland Management.

Government of Oromia Regional State: Socio Economic Profile of East Shewa, (2010).

Hailemariam Teklewold, Alemu Mekonnen and Gunnar Kohin. (2019). Climate change adaptation: a study of multiple climate-smart practices in the Nile Basin of Ethiopia

International Fund for Agricultural development (IFAD), (2013). The adaptation advantage: The economic benefits of preparing small-scale farmers for climate change.

IPCC (2007). Climate change 2007: synthesis report. Working group contribution to the fourth assessment report of intergovernmental panel on climate change.

IPCC (2014). Climate change 2014: Impacts, Adaptation and Vulnerability: Summary for Policymakers.

Jema Haji, (2008). Economic Efficiency and Marketing performance of vegetable production in the Eastern and Central parts of Ethiopia. Doctoral Thesis Swedish University of Agricultural Sciences Uppsala 2008.

Jemal and Kyung – Ryhang Kim, (2014). Determinants of Household Food Security in Rural Ethiopia: An Emperical Analysis.

Jenny C. Aker and Christopher Ksoll, (2015). Call me Educated: Evidence from a Mobile Monitoring Experiment in Niger.

Karpouzoglou, T., & Barron, J. (2014). A global and regional perspective of rainwater harvesting in Sub-Saharan Africa's rain fed farming systems.

Keshavarz.M & Karami.E.. (2014). Farmers decision-making process under drought.

Kidane, H., Alemu, Z. G., & Kundhlande, G. (2005). Causes of household food insecurity in Koredegaga peasant association, Oromiya Region, Ethiopia

Lipper et al., 2014).Lipper L, Thornton P, Campbe BM, et al. (2014) Climate-smart agriculture for food security.

Maddison D, (2006). The perception and adaptation to climate change in Africa. Centre for Environmental Economics and Policy in Africa (CEEPA) Discussion Paper No. 10. Centre for Environmental Economics and Policy in Africa, University of Pretoria, South Africa; 2006

Mahoo H, Radeny M, Kinyangi J, Cramer L, eds. 2013. Climate change vulnerability and risk assessment of agriculture and food security in Ethiopia: Which way forward? CCAFS Working Paper no. 59. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

Marion Napoli, (2010/2011). Towards a Food Insecurity Multidimensional Index (FIMI).

MelkuJirata, Sebastian Grey and Edward Kilawe, (2016).Ethiopia Climate smart Agriculture scoping study, FAO Addis Ababa 2016.

Meskerem and Degefaw, (2015).Household food security status and its determinants in GirarJarso Woreda, North Shewa zone of Oromia region, Ethiopia.

Milder, J., Majanen, T., & Scherr, S. (2011). Performance and potential of conservation Agriculture for Climate Change Adaptation and Mitigation in Sub-Saharan Africa: An Assessment of WWF and CARE projects in Support of the WWF-CARE Alliance's Rural Future Initiative, Final Report, Eco Agriculture Partners and CARE-WWF Alliance.

Ministry of Agriculture & natural Resources, Agricultural Transformation Agency and Ministry of Livestock & Fishery. 2018. Guideline For Mainstreaming CRGE In Agriculture & Livestock Sectors.

Muhammed Urgessa (2011). Market chain Analysis of Teff and Wheat Production in Halaba Special Woreda, southern Ethiopia.

Mul, M. L., Kemerink, J. S., Vyagusa, N. F., Mshana, M. G., Van der Zaag, P., & Makurira, H. (2011). Water allocation practices among smallholder farmers in the South Pare Mountains, Tanzania: The issue of scale.

Mulatu Debalke, Negash, (2011). Determinants of farmers' preference for adaptation strategies to climate change; evidence from north shoa zone of Amhara region Ethiopia,

National Meteorological Agency, (2007).National Adaptation Program of Ethiopia. Final draft report, NMA, Addis Ababa.

Nelson GC, Rosegrant MW, Koo J, Robertson R, Sulser T, Zhu T, Ringler C, Msangi S, Palazzo A, Batka M, Magalhaes M, Valmonte-Santos R, Ewing M, Lee D. (2009). Climate Change Impact on Agriculture and Costs of Adaptation. IFPRI Food policy report.

Nin Pratt, Alejandro & Falconi, Cesar & Ludena, carlos E. & Martel, Pedro, (2015). Productivity and the Performance of Agriculture in Latin America and the Caribbean: From the Lost Decade to the Commodity Boom.

OECD, (2001).Measuring productivity: Measurement of Aggregate and Industry –Level Productivity Growth.

Ogutu..S.O..Okello..D,J.(2014). Impact of information and communication technology based market information services on smallholder farm input use and productivity the case of kenya.

Quiroga.S. Suarez..C.& Solis.. J..D..(2015). Exploring coffee farmers awareness about climate change and water needs: Smallholders perception of adaptive capacity.

Samuel Gebre – Selassie, (2004). Food insecurity and Poverty in Ethiopia: Evidence and Lessons from Wollo. Working Paper No. 3/2004 EEA/Ethiopian Economic Policy Research Institute. December 2004, Addis Ababa.

Samuel Wemiga Amuga, Chris Gordon, Emmannuel Boon and Justice Musah – IssahSurugu (2019). Determinants of Climate Smart Agriculture (CSA) Adoption among Smallholder Food Crop Farmers in the Techiman Municipality, Ghana

Sarah Conradt, Robert Finger, Martina Sporri, (2015). Flexible weather index – based insurance design.

Shannon. H..D. & Motha.. R. P (2015). Managing weather and climate risks to agriculture in North Ameroca, Centeral America and the Caribbean.

StataCorp. 2013. Stata statistical software: Release 13. College Station. Stata Corp LP.

Tamiru Lemi and FekaduHailu.(2019). Effects of Climate Change Variability on Agricultural Productivity.

Teklu, E., Stahr, K. and Gaiser, T. (2006).Soil tillage and crop productivity on a vertisol in Ethiopian highlands.

Tesema Urgessa, (2015). The Determinants of Agricultural Productivity and Rural Household income in Ethiopia. A Thesis Submitted to the Department of Economics in Partial Fulfillment of the Requirements for the Degree of Master of Science in Economics (Economic Policy Analysis).

Tewodros Beyene, (2018). Adoption of Climate Smart Agricultural Practices: Determinants and Challenges in Gerar Jarso Woreda of Oromia Regional State, Ethiopia.

USDA (2015). Brown, M.E.., J.M. Antle, P.Backlund, E.R. Carr, W.E.Easterling.,M.K. Walsh.,C.Ammann, W.Attavanich, C.B. Barrett.,M.F. Bellemare, V,dancheck, C.Funk, K.Grace.J.S.I.Ingram,H.Jiang,H.Maletta,T.Mata,A.Murray.M..Ngugi,D.Ojima,B,O'Neil, and C.Tebaldi,2015. Climate change, Global Food Security and the U.S. Food system.

Waqar Akram, Irum Naz and Sadia Ali, (2011). An Empirical Analysis of Household Income in Rural Pakistan: Evidences from Tehsil samundri.

World Bank, (2001).Social protection sector strategy; from safety net to Springboard.

World Bank, (2010) World Development Report 2010: Development and Climate Change. World Bank, Washington DC.

World Bank, (2011). Ethiopia: Climate Risk Fact Sheet

World Bank, (2017).Agricultural productivity in Sub –Saharan Africa.

Yamane, Taro, (1967). Statistics, An Introductory Analysis, 2nd Ed., New York: Harper and Row.

Yibekal A Tessema, Chanyalew S Aweke and Getachew S Endris, (2013).Understanding the process of adaptation to climate change by small-holder farmers: the case of east Hararghe zone, Ethiopia.

Yohanes, G. & Mebratu, K. (2009) local innovation in climate-change adaptation by Ethiopian pastoralists: PROLINNOVA- Ethiopia and pastoralist forum Ethiopia (PEE), Final Report. Addis Ababa

Zhang. X, Rockmore, M & Chamberlin. J (2007).A typology for vulnerability and agriculture Saharan Africa.

APPENDIX I: CONVERSION FACTORS USED TO DETERMINE TROPICAL LIVESTOCK UNIT (TLU) OF SAMPLE HOUSEHOLD

No	Livestock type	TLU
1	Cow/Oxen	1
2	Donkey/Horse	.7
3	Poultry	.013
4	Sheep/Goat	.13
5	Calf	.25
6	Heifer	.75

Source:

APPENDIX II: FOOD COMPOSITION TABLE

Food Grain	Dietary energy Kcal/100gram
Teff	161.20
Wheat	170.18
Chickpea	227.00
Lentil	93.50
Bean	127.4

Source: Survey data and EHNRI's food composition table

APPENDIX III: REGRESSION OUTPUTS FOR:HOUSEHOLD FOOD SECURITY

Sources	SS	df	MS	Number of obs	=	204
Model	103.569507	17	6.09232392	F(17, 186)	=	2.45
Residual	461.77161	186	2.48264307	Prob> F	=	0.0017
Total	565.341117	203	2.78493161	R – squared	=	0.1832
				Adj R - squared	=	0.1085
				Root MSE	=	1.5756
Food_ security	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
Sex	.0522822	.2114321	0.25	0.805	-.3648311	.4693954
Age	.0084911	.0064623	1.31	0.019	-.0042577	.02124
edu_level	-.146247	.112094	-1.30	0.194	-.367386	.074892
Family_size	-.1473084	.0426583	-3.45	0.001	-.2314646	-.0631521
Family labor size	.0082853	.0502389	0.16	0.869	-.0908259	.1073965
Hectar	.0458484	.0886906	0.52	0.606	-.1291204	.2208173
TLU	.0423488	.0190695	2.22	0.028	.0047284	.0799692
Contact_frequency	.0653591	.0560026	1.17	0.245	-.0451228	.1758411
Instituation	.0264094	.1457583	0.18	0.856	-.2611425	.3139614
Dist_buy_input	-.0136149	.0035442	-3.84	0.000	-.0206068	-.006623
Dist_sell_output	.0034448	.0029522	1.17	0.245	-.0023794	.0092689
Market_info	.0152227	.1046795	0.15	0.885	-.1912891	.2217344
Wheather_info	.0210253	.1997479	0.11	0.917	-.3801802	.4222308
Fertlity	.1755876	.1501656	1.17	0.244	-.1206592	.4718344
Possess_Irrigation	.3149392	.144217	2.18	0.030	.0304279	.5994504
Nonfarm_Income	.3120486	.1322645	-2.36	0.019	-.5729801	-.0511171
CSAIntensity	.1259517	.0584658	2.15	0.036	-.2433836	-.0085198
_cons	7.743363	1.862617	4.16	0.000	4.002187	11.48454

HOUSEHOLD INCOME

sources	SS	df	MS	Number of obs	=	204
Model	37.7196426	17	2.2188025	F(17, 186)	=	7.14
Residual	57.7770049	186	.310629059	Prob> F	=	0.0000
Total	95.4966475	203	.470426835	R – squared	=	0.3950
				Adj R - squared	=	0.3397
				Root MSE	=	.55734
Income	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
Sex	-.0360308	.1685678	-0.21	0.831	-.3685814	.2965198
Age	.0072841	.0051522	1.41	0.159	-.0028801	.0174483
edu_level	-.0372585	.0893688	-0.42	0.677	-.2135653	.1390483
Family_size	-.0255814	.03401	-0.75	0.453	-.0926764	.0415136
Family labor size	-.0496077	.0400538	-1.24	0.217	-.1286258	.0294104
Hectar	.1519767	.0707101	2.15	0.033	.0124798	.2914735
TLU	-.0052252	.0152035	-0.34	0.731	-.0352186	.0247683
Contact_frequency	-.0445192	.044649	-1.00	0.320	-.1326028	.0435644
Instituation	-.1212388	.1162083	-1.04	0.298	-.3504945	.1080169
Dist_buy_input	-.0006704	.0028256	-0.24	0.813	-.0062449	.004904
Dist_sell_output	-.0062778	.0023537	-2.67	0.008	-.0109212	-.0016344
Market_info	.0986249	.0834575	1.18	0.023	-.0660201	.2632699
Wheather_info	-.4218649	.1054501	-4.00	0.000	-.6298969	-.2138328
Fertlity	-.1927199	.1197221	-1.61	0.109	-.4289076	.0434679
Possess_Irrigation	.1546981	.1149794	1.35	0.018	-.0721333	.3815295
Nonfarm_Income	.2541996	.1035671	2.45	0.015	.0498825	.4585167
CSAIntensity	.1335654	.0274599	4.86	0.000	.0793925	.1877384
_cons	10.56977	.4689923	22.54	0.000	9.644543	11.495

CSA ADOPTION INTENSITY

sources	SS	df	MS	Number of obs	=	204
Model	569.208035	16	35.5755022	F(16, 187)	=	16.15
Residual	411.948828	187	2.20293491	Prob> F	=	0.0000
Total	981.156863	203	4.83328504	R – squared	=	0.5801
				Adj R - squared	=	0.5442
				Root MSE	=	1.4842
CSA Intensity	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
Sex	.9472203	.4435287	2.14	0.034	.0722575	1.822183
Age	.0246315	.0136018	1.81	0.072	-.0022012	.0514641
edu_level	-.3792504	.2363724	-1.60	0.110	-.8455496	.0870488
Family_size	.1765921	.0896451	1.97	0.050	-.0002537	.3534379
Family labor size	-.5002558	.1001959	-4.99	0.000	-.6979154	-.3025962
Hectar	.5068512	.1846209	2.75	0.007	.1426438	.8710586
TLU	.0127816	.040477	0.32	0.753	-.0670685	.0926318
Contact_frequency	.7472577	.105602	7.08	0.000	.5389333	.9555821
Instituation	.6415486	.305892	2.10	0.037	.0381059	1.244991
Dist_buy_input	.0251681	.0072963	3.45	0.001	.0107745	.0395617
Dist_sell_output	-.0039562	.0062614	-0.63	0.528	-.0163082	.0083957
Market_info	.0685042	.2221953	0.31	0.758	-.3698274	.5068358
Wheather_info	.8264819	.2742384	3.01	0.003	.2854834	1.36748
Fertlity	.2413083	.3183376	0.76	0.449	-.3866862	.8693027
Possess_Irrigation	1.222632	.2928522	4.17	0.000	.6449138	1.800351
Nonfarm_Income	.0000488	.0000129	3.77	0.000	.0000233	.0000743
_cons	5.727212	1.176636	4.87	0.000	3.406025	8.048399

APPENDIX IV: LINEARITY TEST FOR:

HOUSEHOLD FOOD SECURITY

sources	SS	df	MS	Number of obs	=	204
Model	569.208035	16	35.5755022	F(16, 187)	=	16.15
Residual	411.948828	187	2.20293491	Prob> F	=	0.0000
Total	981.156863	203	4.83328504	R – squared	=	0.5801
				Adj R - squared	=	0.5442
				Root MSE	=	1.4842
Food security	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
_hat	1.252607	.3768074	3.32	0.001	.5096043	1.99561
_hatsq	-.0000102	.0000145	-0.70	0.485	-.0000389	.0000185
_cons	-1175.614	2306.105	-0.51	0.611	-5722.876	3371.647

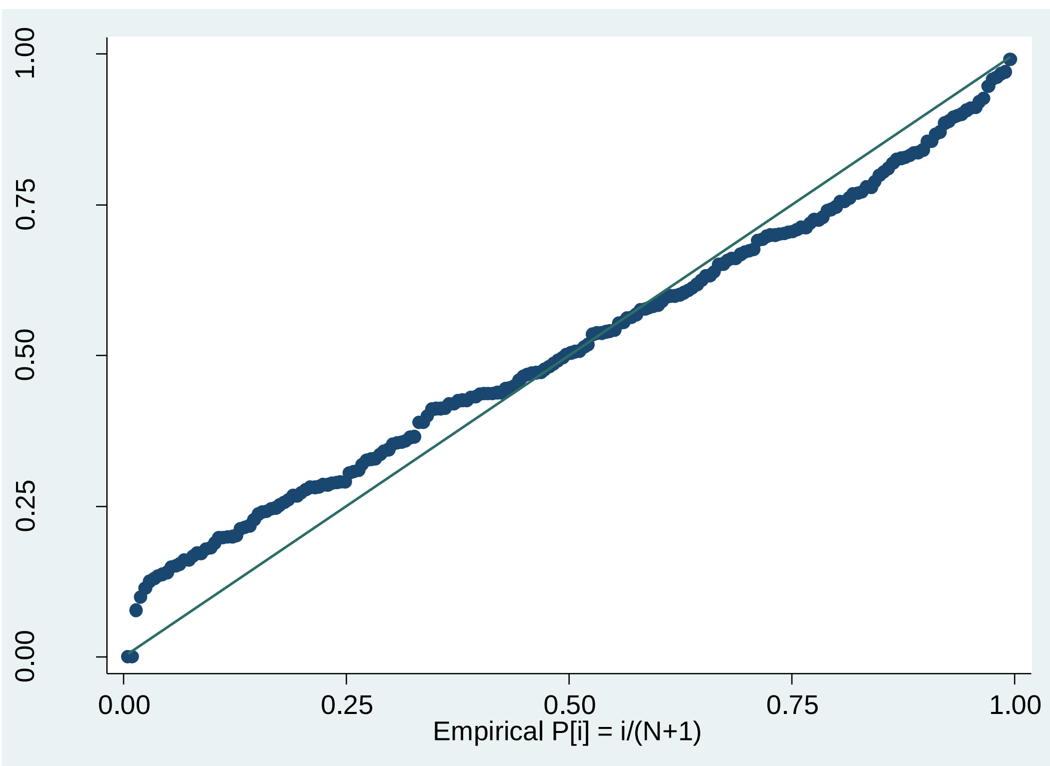
HOUSEHOLD INCOME

sources	SS	df	MS	Number of obs	=	204
Model	39.7036552	2	19.8518276	F(2, 201)	=	71.52
Residual	55.7929923	201	.277577076	Prob> F	=	0.0000
Total	95.4966475	203	.470426835	R – squared	=	0.4158
				Adj R - squared	=	0.4099
				Root MSE	=	.52686
Income	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
_hat	4.611316	3.363442	1.37	0.172	-2.020841	11.24347
_hatsq	-.1620552	.150885	-1.07	0.284	-.4595759	.1354654
_cons	-20.08698	18.72613	-1.07	0.285	-57.01185	16.83788

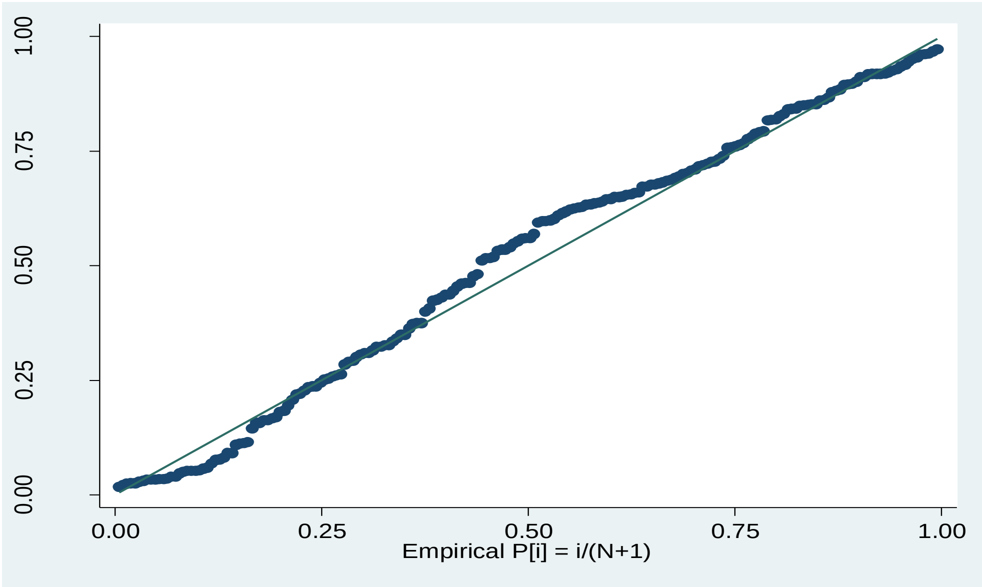
CSA ADOPTION INTENSITY

sources	SS	df	MS	Number of obs	=	204
Model	573.65421	2	286.827105	F(2, 201)	=	141.48
Residual	407.502653	201	2.02737638	Prob> F	=	0.0000
Total	981.156863	203	4.83328504	R – squared	=	0.5847
				Adj R - squared	=	0.5805
				Root MSE	=	1.4239
Income	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
_hat	2.081132	.7324852	2.84	0.005	.6367912	3.525473
_hatsq	-.0430071	.0290411	-1.48	0.140	-.1002714	.0142573
_cons	-6.67148	4.565552	-1.46	0.146	-15.674	2.331042

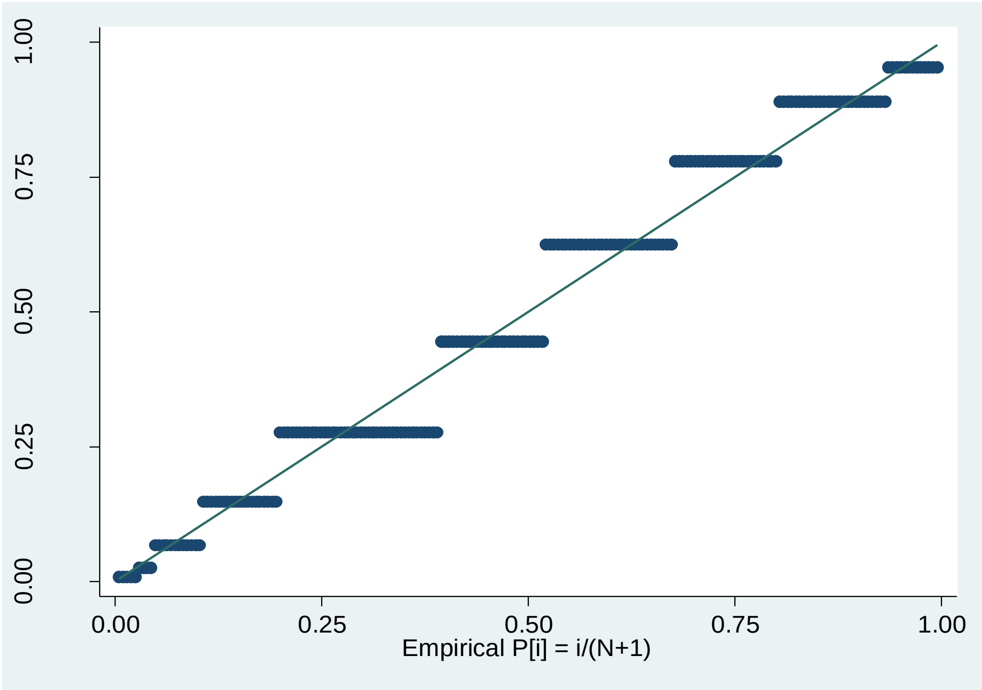
APPENDIX V: NORMALITY TEST FOR:
HOUSEHOLD FOOD SECURITY



INCOME



CSA ADOPTION INTENSITY



APPENDIX VI: MULTICOLINARITY TEST BETWEEN THE VARIABLES USED IN THE REGRESIONS

Variable	VIF	1/VIF
Dist_sell_output	2.83	0.352898
Dist_buy_input	2.57	0.389119
CSAIntensity	2.21	0.451827
Hectar	2.10	0.476141
Family labor size	2.04	0.489990
TLU	1.80	0.556129
Wheather_info	1.79	0.557442
Age	1.73	0.577228
Irrigation	1.67	0.597070
Extension	1.59	0.629728
Family_size	1.52	0.659593
Fertlity	1.19	0.838338
Market_info	1.14	0.876592
Institutions	1.14	0.877367
Sex	1.11	0.900565
edu_level	1.11	0.902864
Mean VIF	1.72	

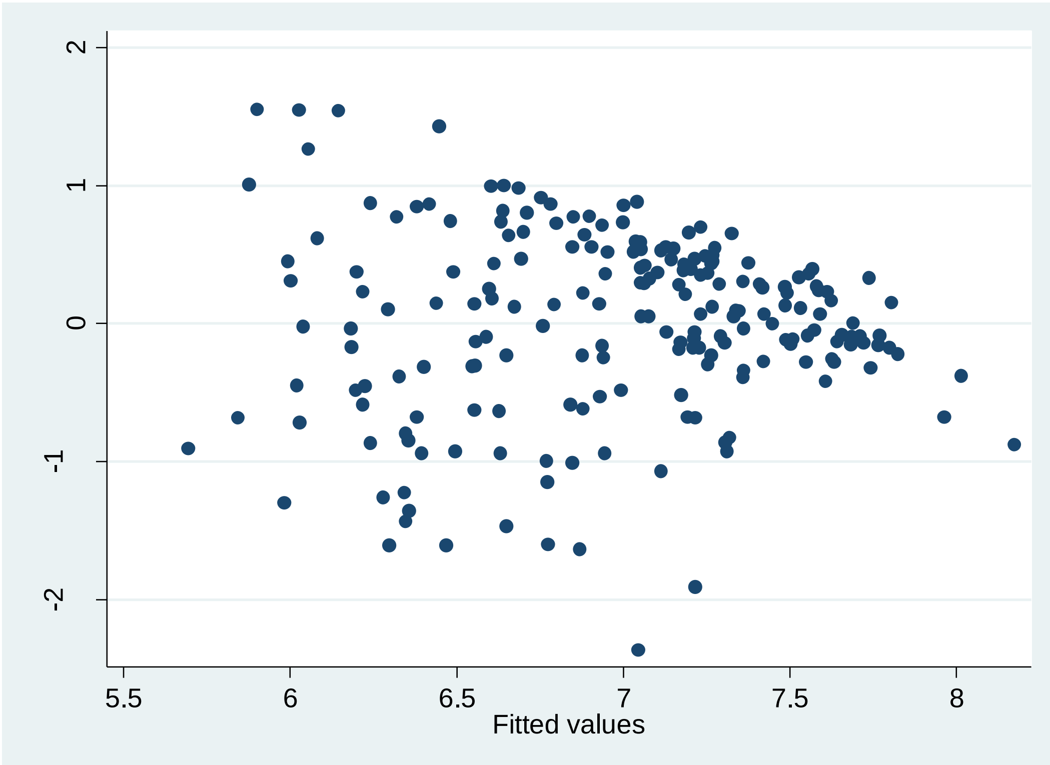
APPENDIX VII: HETEROSKEDASTICITY

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

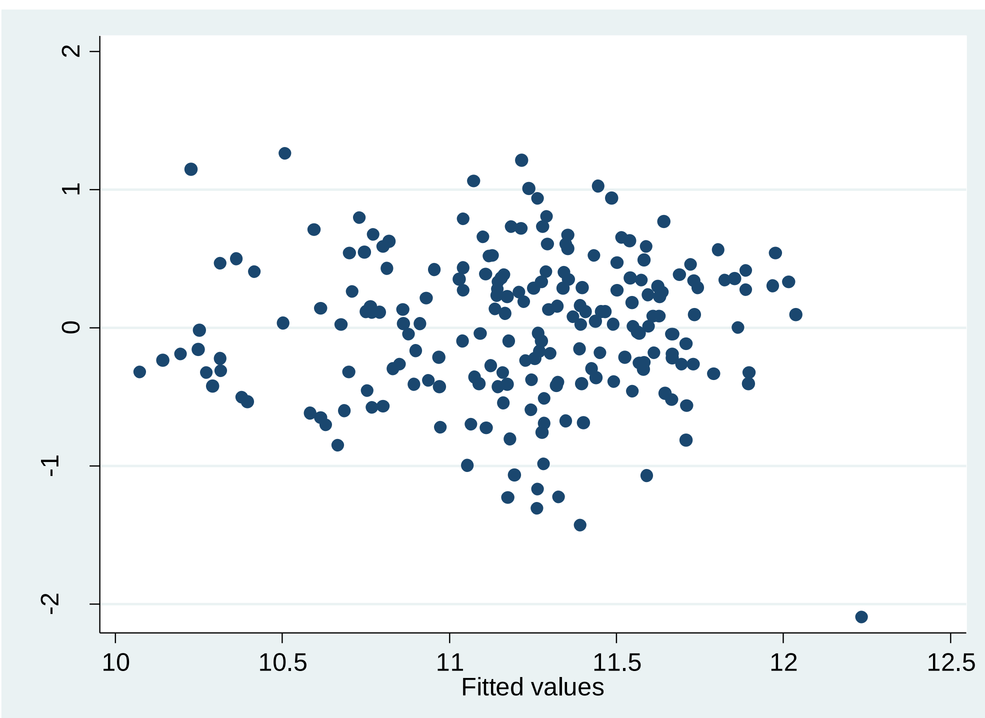
Ho: Constant variance

	Food security	**Income**	**CSA intensity**
Chi2	3.03	1,04	1.27
Prob>chi2	0.0816	0.3087	0.2597

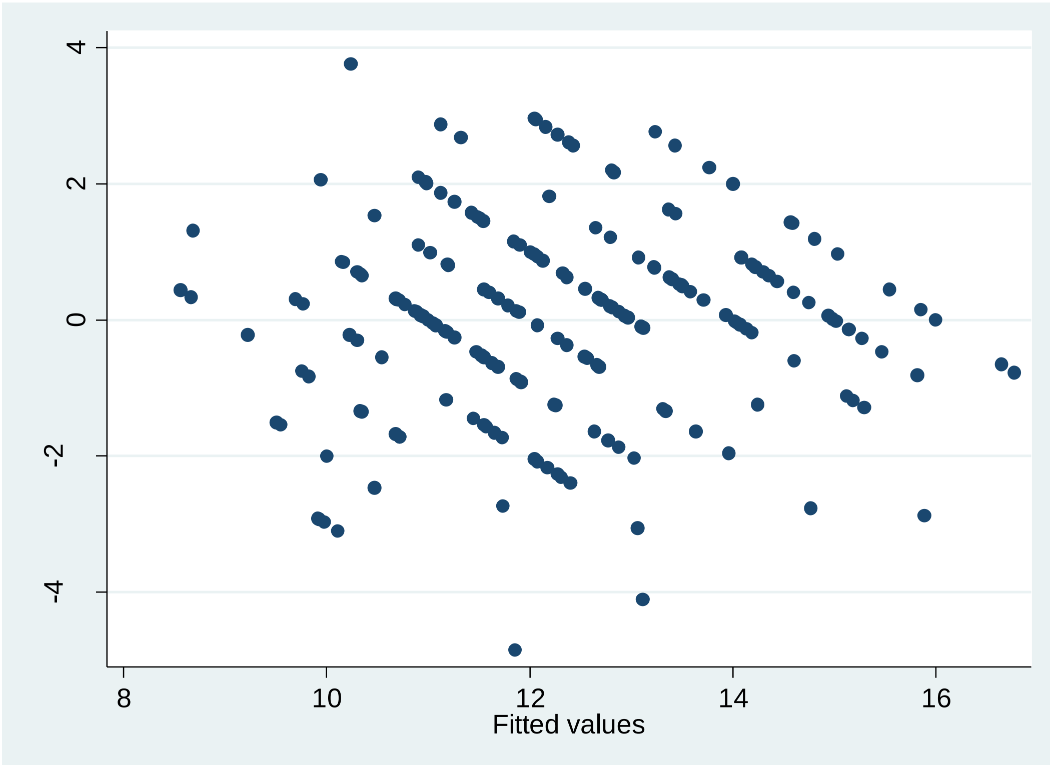
FOOD SECURITY



INCOME



CSA ADOPTION INTENSITY



Appendix VIII: Household Questionnaire

THE ADOPTION INTENSITY OF CLIMATE SMART AGRICULTURE PRACTICES ON INCOME AND FOOD SECURITY AMONG WHEAT AND TEFF GROWERS IN GIMIBICHU WOREDA, OROMIA REGION, ETHIOPIA

The objective of the interview is to collect data for MSc research conducted for the purpose of education and all information provided will be simply used for education purpose and remain confidential. Your full support and willingness to respond to the question is very essential for the success of the study. Therefore, you are kindly requested to answer all questions and give clear and reliable information on the issues. Please feel free to convey the required information honestly. Thank you in advance for your cooperation.

Sincerely,

Kena Ghimbi

Postgraduate student at Addis Ababa University

College of Development studies

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Email: Kenawaq450@gmail.com

Name of kebele:____

ID of Respondent:______________________________

Date of Interview:______________________________

Section A. Household Demographic factor related questions

1. Sex of Household head: ______________________________
2. Age (Years):____________________________
3. Level of Education: 1. Literate 0 = Illiterate
4. Marital status: 1= Married; 2=Single; 3=Divorced; 4=Widowed; 5=other (specify)

5. Family size:

Number of family members		
Age	Male	Female
<15		
15 – 64		
>64		

Section B: Socio – Economic Factor Related Questions

1. Do you own land? 1=yes 0=No
2. If yes, how many hectares (timad) of land do you have? ______________________
3. Which farming activities are you following currently? 1= only crop production 2= livestock rearing 3= mixed farming (crop production and livestock rearing)
4. How much income did you generate from your farming activities during last production year (i.e. 2010/2011)? Specify in birr________________________________

From crop production

Type of Crop grown	Quantity produced	Quantity consumed for household food	Quantity sold	Average price (birr/quintal)	Estimated income earned	Production costs	Area cultivated in hectare
Teff							
Wheat							
Barley							
Chickpea							
Field Beans							
Lentil							
Sorghum							
Maize							
Beans							
Others (specify)							

From Livestock production

Livestock Type	Size (quantity) possessed by the household	No of livestock sold	Average price	Income earned
Cow				
Oxen				
Heifer				
Calf				
Bull				
Sheep				
Goat				
Poultry				
Horse				
Donkey				
Poultry				
Others				

Section C: Household Food Security Measurement

Type of Crop grown	Total Grain bought in kilogram	Quantity of food aid obtained in kilogram	Total Grain obtained through gift or remittance in kilogram	Post-harvest loosed in kilogram	Quantity of grain reserved for seed kilogram	Grain given to otherS kilogram
Teff						
Wheat						
Barley						
Chickpea						
Field Beans						
Lentil						
Sorghum						
Maize						
Beans						
Others (specify)						

16. Would you please estimate the total annual income you got from the sale of non-cereal crops (vegetables, fruits etc) produced by your household in 2010/11 (Birr):

17. Do any members of your family have any sources of off-farm income? 1=Yes 0= No

18. How much income did you generate from your off - farming activities during last production year (i.e. 2010/2011)? Specify in birr: ______________________________

Section D: Question Related with Access of Institutions

1. Do you have contact to agricultural extensions services? 1=Yes 0= No
2. If yes how many times extension worker averagely visit you in a production season? ____ ____________
3. Are you a member of any formal/informal institutions in your village? 1=Yes 0= No
4. How long does it take to reach market center where you buy your agricultural inputs? Distance in KM……………….in terms of time it takes (in minutes)______
5. How long does it take to reach market center where you sale your agricultural production? Distance in KM……………..in terms of time it takes (in minutes)………..
6. Do you have regular access to whether information? 1=Yes 0= No
7. Do you have regular access to market information? 1=Yes 0= No

Section E: Question on Adoption of climate smart crop production practices

1. The level of fertility of the farm land: 1. Fertile 2. Moderately fertile 3.Less fertile 4. Infertile
2. Does the household possess an irrigated agriculture? 1=Yes 0= No
3. Have you employed any of the following climate smart crop production practices in your wheat and/or Teff farm in the season of production (2010/11)?

CSA Practice	Components	Yes/No
Conservation Agriculture	• Reducing tillage	
	• Crop residue management – mulching, intercropping	
	• Crop rotation/intercropping with cereals and legumes	
Integrated soil fertility management	• Compost and manure management, including green manuring	
	• Efficient fertilizer application techniques (time, method and amount)	
Small – scale irrigation	• Year round cropping	
	• Efficient water utilization	
Agroforestry	• Tree based conservation agriculture (planting and managing trees)	
	• Practiced both traditionally and as improved practice	
	• Farmer – managed natural regeneration	
Crop diversification	• Popularization of new crops	
	• Popularization of crop varieties	
	• Pest resistance	
	• high yielding	
	• tolerant to drought	
	• short season	