DETERMINANTS OF CLIMATE SMART CROP PRODUCTION PRACTICES BY SMALL HOLDER FARMERS IN SHASHEMANE DISTRICT, CENTRAL RIFT-VALLEY OF ETHIOPIA

BY

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JUNE, 2020

WANDO GENET

ETHIOPIA

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A THESIS SUBMITTED TO THE SCHOOL OF POST GRADUATE STUDIES OF HAWASSA UNIVERSITY, WONDO GENET COLLEGE OF FORESTRY AND NATURAL RESOURCE, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN CLIMATE SMART AGRICULTURAL LANDSCAPE ASSESSMENT

BY

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DECLARATION

I declare that this Msc. thesis work entitled “Determinants of Climate Smart Crop Production Practices by Small Holder Farmers in Shashemane District, Central Rift-Valley of Ethiopia” is my original work and has not been submitted for a degree of award in any other university and all sources of material used in this thesis have been properly acknowledged.

Yeshiget Mengistu Teshite ____________________ ____________________

Name of Student Signature Date

APPROVAL SHEET I

This is to certify that the thesis work entitled "Determinants of Climate Smart Crop Production Practices by Small Holder Farmers in Shashemane District, Central Rift-Valley of Ethiopia" submitted in partial fulfillment of the requirements for the degree of master of science in Climate Smart Agriculture Landscape Assessment, the graduate program of the Department of Agro forestry, and has been carried out by Yeshiget Mengistu Teshite, under our supervision. Therefore, we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

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Name of Main Advisor	Signature	Date
Dr. Kidist Fikadu	__________________________	____________________
Name of Co- Advisor	Signature	Date

APPROVAL SHEET II

We, the Undersigned, members of the board of examiners of the final open defense by Yeshiget Mengistu Teshite have read and evaluated her thesis work entitled "Determinants of Climate Smart Crop Production Practices by Small Holder Farmers in Shashemane District, Central Rift-Valley of Ethiopia" and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of Master of Science in Climate Smart Agriculture Landscape Assessment.

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Name of the Chairperson	**Signature**	**Date**
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Name of External Examiner	**Signature**	**Date**
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Name of Internal Examiner	**Signature**	**Date**
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Name of the Major Advisor	**Signature**	**Date**
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Postgraduate Approval	**Signature**	**Date**

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LIST OF ABBREVIATIONS AND ACRONYMS

ADLI	Agricultural development-led industrialization
ADB	African Development Bank
AGP	Agricultural Growth Program
ATA	Agricultural Transformation Agency
ACSAA	Africa Climate-Smart Agriculture Alliance
AU	African Union
BOA	Bureau of Agriculture
CA	Conservation agriculture
CAADP	Africa Agriculture Development Program
CAWT	Conservation agriculture with trees
CBD	Convention on Biological Diversity
CCF-E	Climate Change Forum - Ethiopia
CDM	Clean Development Mechanism
CFGB	Canadian Food grains Bank
CGIAR	Consultative Group for International Agricultural Research
CRGE	Climate Resilient Green Economy
CSA	Climate-smart agriculture
DA	Development agents
DRMFS	Disaster Risk Management and Food Security
DRSLP	Drought Resilient and Sustainable Livelihoods Program
ECRGE	Ethiopian Climate-Resilient Green Economy
EIA	Environmental Impact Assessment
EIAR	Ethiopian Institute of Agricultural Research
EPA	Environmental Protection Agency
EPACC	Ethiopian Program of Adaptation to Climate Change
FAO	Food and Agriculture Organization of the United Nations
FDRE	Federal Democratic Republic of Ethiopia
FGD	Focus group discussion
FRC	Forestry Research Centre

GDP	Gross domestic product
GHG	Greenhouse gas
GTP	Growth and Transformation Plan
ICRAF	International Centre for Research in Agro forestry
KII	Key informant interview
LWRC	Land and Water Resource Centre
MoA	Ministry of Agriculture
NAMA	Nationally Appropriate Mitigation Actions
NAPA	National Adaptation Program of Action
NGO	Non-governmental organization
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SLM	Sustainable land management
SLMP	Sustainable Land Management Program
SOC	Soil organic matter content
SPI	Standard Precipitation Index
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCC	United Nations Framework Convention on Climate Change

DETERMINANTS OF CLIMATE SMART CROP PRODUCTION PRACTICES BY SMALL HOLDER FARMERS IN SHASHEMANE DISTRICT, CENTRAL RIFT-VALLEY OF ETHIOPIA

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ABSTRAC

The world's climate is changing and will continue to change until strong action is taken to combat the effect of climate change on human livelihoods especially in Sub-Sahara Africa where capacities to cope are limited. Although there are several determinant factors that prevent smallholder farmers of Ethiopia to adopt CSA crop production so far, existing policies and actions to alleviate these obstacles remain inadequate. This study was therefore conducted to assess the determinants of the application of climate smart agricultural crop production practices in Shashamene woreda. A simple random sampling technique was employed to select 361 sample households for this study. To identify the existence of climate variability in the study area, thirty six (1981- 2016) years' rainfall and temperature data from NMA were analyzed and compared with farmers' perceptions. Descriptive statistics such as percentage and frequency, binary logistic regression and MNL model were used to identify the perception of smallholder farmers towards climate change as well as major determinants of the application of CSA crop production practices. The results obtained from the long term climate data showed that, the inter-annual rainfall is relatively stable in amount and less variable in occurrence, while mean annual maximum and minimum temperatures less in inter-annual variability, but with consistent and steady annual increases by 0.031 and 0.018^{0}C respectively. These results were in line with farmers view on temperature and precipitation variabilities observed in the binary logistic model. Descriptive statistics indicated climate smart agricultural crop production practices used by smallholder to cope the adverse effects of climate change were; precise fertilizer application, Integrated pest management, Use of improved varieties, Response farming, Organic and bio fertilizer application, Conservation agriculture and crop diversification were;, 46.5%, 42%, 58.4%, 49%, 77.6% and 57.6% respectively. The MN logistic regression analysis results also showed that age of household, family size, training and extension service, education, farm size, livestock asset, access to credit, farmers view on rainfall variability and farmers view on temperature variability were found to positively and significantly influence the application of these climate smart agricultural crop production practices in the study area. Thus, most of the farmers are not exercising CSA crop production practices, despite they are well aware of the changes in rainfall and temperature. This is mainly due to the limitations associated with; weather information and extension services, level of farmers education, credit access, which should be addressed by the concerned bodies. Therefore, the issue of CSA in crop production practices has to receive due attention in an effort to ensure sustainability of the rural livelihood system and food security goal of the country in the face of climate change *through all stockholders engagements to address the decisive impacts of the identified determining factors.*

Key words: Climate smart, climate variability, climate change perception, livelihood, food security, stockholder

1 INTRODUCTION

1.1 General Background

Climate change is a threat to food security systems and one of biggest challenges in the 21stcentury (FAO, 2013). It is widely accepted that the ability to contain the pace of climate change by keeping temperature rise within 2°C threshold in the long run is now limited and the global population will have to deal with its consequences (IPCC, 2014). Agricultural production systems are expected to produce food for the global population that is expected to reach 9.1 billion people in 2050 and over 10 billion by end of the century (World Bank, 2011). According to Branca *et al*., (2011), agricultural systems need to be transformed to increase the productive capacity and stability of smallholder agricultural production in the wake of climate change.

Climate change imposes constraints to development especially among smallholder farmers whose livelihoods mostly depend on rainfed agriculture (IPCC, 2007). Negative impacts of extreme events such as floods and droughts are expected to be high in developing countries especially in rural areas (IPCC, 2007; Adger *et al.*, 2003). Adverse effect of climate change continues to be a major threat to rural livelihoods (Nhemachena C., 2009; Pouliotte *et al.*, 2009; IPCC, 2007; Adger *et al.*, 2003). This poses a challenge of developing innovative technology to improve rural livelihoods and environmental conservation and ensuring adoption of such technologies. Sub-Sahara Africa is among the most vulnerable regions to climate change impacts, because the majority of the Sub-Sahara African population lives in horrible poverty, and heavily dependent on rainfed agriculture for economic and livelihood sustenance.

Accordingly, agriculture is the economic foundation of Ethiopia, employing about 72.7 percent of the workforce and contributing nearly 36 percent of gross domestic product and 81 percent of foreign exchange earnings (NBE, 2018). Despite the marginal decline in its share in GDP in recent years, agriculture is still the key sector in terms of its contribution to macroeconomic development of Ethiopia. To sustainably enhancing the livelihood status of smallholder farmers, the agricultural sector needs suitable climatic condition, despite, Ethiopia's climate is changing, and rainfall patterns are set to alter. In many areas droughts become more frequent, more intense, and last longer (Belay and Getaneh, 2016), while new unpredictable patterns of rainfall occurring related to flooding and soil erosion.

Therefore, Climate change is emerging as one of the major threats to the national development (Belay, 2016). Since, agriculture is highly vulnerable to climate change, food insecurity remains a concern among million's. Ensuring food security under a changing climate is one of the major challenges of our time. To combat these adverse effects of climate change several measures have been suggested in attempts to reduce the vulnerability of smallholder farmers who are the most affected by changes in climate.

One of such impacts intervention is climate smart agriculture (CSA) practices as especially directed in (FAO, 2010) document as a climate change impacts solution, and probably one of the most viable and sustainable option. It offers triple wins; mitigation and adaptation measures to climate changes, while sustainably increasing agricultural productivity and incomes.

Nowadays, the need and implementation practices of CSA are growing among different development capacity building agencies. In most cases to implement eco- friendly agricultural practices, agro ecological assessments are done. Soil type, precipitation level and temperature status are the common parameters analyzed to adopt innovative agricultural practices (CASCAPE, 2016).

1.2 Statement of the problem

Adverse effects of the climate change and variability is a major threat to smallholder farmers and rural livelihoods of our country. Ethiopia has low level of economic development with its heavy dependence on rainfed agriculture which is most vulnerable sector to climate change, and makes the country susceptible to the adverse effects of climate change.

Especially the central rift valley of Ethiopia has long been considered as Ethiopia's most climate-prone area, and Shashemene woreda, is one of the West Arsi Zone of Oromia regional state in the Rift valley. Shashemane woreda is among the vulnerable areas to climate change and variability, where the farming system is characterized by low productivity, low use of farm inputs, traditional farm practices, poor soil fertility and along with socioeconomic related problems. Several actions have been recommended in attempts to decrease the exposure of smallholder farmers who are the most affected by the changes in climate. One of such interventions is climate smart agriculture (CSA) practice as a climate change impact solution (FAO, 2010).

However, the adoption of climate smart agricultural practices by the farming community in the woreda is far under the expectation. Besides, adaptations of CSA practices, several studies were conducted in Ethiopia at macro scale, still site specific studies at micro scale research is vital for effective intervention measures. It would be hard to attain sustainable agricultural productivity at the face of climate change, without a critical assessment on the adaptation potential of the target groups beyond agroecological parameters;

This research was therefore, initiated with the aim to assess the determinants for successful implementation of climate smart crop production practices by smallholder farmers in Shashemane district of Oromia regional state..

1.3. Objectives of the study

- To assess long term trends of climate variability and climate change in the study area
- To examine farmers' perceptions on climate change and assess their views towards Climate Smart Agricultural crop production practices.
- To examine the major determinant factors affecting farmers' adoption and implementation of climate smart agricultural practices.

1.4. Research questions

The research was planned to answer the following important questions;

1. What are the observed trends of the climate especially rainfall and temperature in the area
2. How Climate Smart Agricultural crop production practices are currently being used by small scale farmers?
3. What socio-economic, institutional and climate related factors influence the adoption of Climate Smart Agricultural practices?
4. What are the determinants of choice and implementation of Climate Smart Agricultural practices on smallholder farmers?

1.5. Significance of study

Climate change is raising threats for agricultural production and productivity. The high vulnerability nature of the sector demands implementation of climate smart agricultural practices to enhance sustainable agricultural productivity through simultaneous actions of adaptation and mitigation.

There are various determinants that positively or negatively contribute towards implementation of CSA crop production practices. Identification of these determinants in woreda level are critically important for policy makers, researchers and any respective organizations involved in application of CSA crop production practices in their development programs to enhance the livelihoods of rural households. Assessing the acceptance level of rural farmers, could also be useful for designing policies to enhance their capacity to reduce greenhouse gas emissions and cope with climate change risks and impacts.

1.6. Scope and limitation of the study

The study was conducted in Shashemene woreda of Oromia region, which is not expected to represent the whole part of Ethiopia. But the result still can be use full for other adjacent woreds of Oromia region with similar agro ecology. On the other hand, a climate smart agricultural practice comprises numerous practices but the study focused only on climate smart crop production activities due to the constraints of time and finance.

2. REVIEW OF LITERATURE

2.1. Climate Change and Agriculture

Climate change is a change of climate which is attributed directly or indirectly to human activity. It alters the composition of the global and/or regional atmosphere and natural climate variability observed over comparable time periods (IPCC, 2015). Climatic variability are the types of changes (temperature, rainfall, occurrence of extremes); magnitude and rate of the climate change that causes the impacts on the area of public health, agriculture, food security, forest hydrology and water resources, coastal area, biodiversity, human settlement, energy, industry, and financial services(FAO, 2017). Changes in physical and socio-economic system have been identified in many regions (UNFCCC, 2007).

According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), the global average surface temperature is likely to rise by 1.8 degrees to 4.0 degrees Celsius by 2100. The sea level may rise by 30 to 60 centimeters. Climate variability will increase almost everywhere. Northern latitudes will experience more rainfall; many subtropical regions will see less (IPCC, 2001).

Detecting these changes and associating them with climate change poses huge problems since these systems are usually subject to many stress factors other than climate change too. Vulnerability is the degree to which a system (such as a social-ecological system) is likely to be wounded or experience harm or stress in the natural or social environment (FAO, 2013). Vulnerability results from a combination of processes that shape the degrees of exposure to a hazard, sensitivity to its stress and impacts, and resilience in the face of those effects. It is also considered a characteristic of all people, ecosystems, and regions confronting environmental or socioeconomic stresses and, although the level of vulnerability varies widely, it is generally higher among poorer people (Belay, 2016).Baseline climate that was developed using historical data of temperature and precipitation from 1971-2000 for selected stations in Ethiopia showed the year-to-year variation of rain fall for the period between 1951 to 2005 over the country expressed in terms of normalized rainfall anomaly averaged for 42 stations (NMA, 2007). The country during those periods (1951 to 2005) has experienced both dry and wet years over the last 54 years. These changes in the physical environment are expected to have an adverse effect on agricultural production, including staple crops such as wheat and maize. Trend analysis of annual rainfall in Ethiopia shows that rainfall remained more or less constant when averaged over the whole country while a declining trend has been observed over the Northern and Southwestern Ethiopia (IPCC, 2007).The rainfall is highly variable both in amount and distribution across regions and seasons. The seasonal and annual rainfall variations are results of the macro-scale pressure systems and monsoon flows which are related to the changes in the pressure systems. The spatial variation of the rainfall is influenced by the changes in the intensity, position, and direction of movement of these rain-producing systems over the country (Temesgen, 2000). Moreover, the spatial distribution of rainfall in Ethiopia is significantly influenced by topography which also has many unexpected changes in the Rift Valley. Being a closed basin, relatively small interventions in land and water resources can have far-reaching consequences for ecosystems goods and services, and potentially undermine the sustainable use of the area.

The National Metrological Agency (2001) revealed that in Ethiopia climate variability and change in the country is mainly manifested through the variability and decreasing trend in rainfall and increasing trend in temperature. Besides, rainfall and temperature patterns show large regional differences. For the IPCC mid-range emission scenario, the mean annual temperature will increase in the range of 0.9 -1.1 °C by 2030, in the range of 1.7 - 2.1 °C by2050 and in the range of 2.7-3.4 °C by 2080 over Ethiopia compared to the 1961-1990 normal (USAID, 2012). A small increase in annual precipitation is expected over the country.

Historical climate analysis for Ethiopia indicates that mean annual temperature has increased by 1.3°C between 1960 and 2006, an average rate of 0.28°C per decade (Ibid). The increase in temperature in Ethiopia has been most rapid in June, August, and September at a rate of 0.32°C per decade. Rainfall is historically highly variable and there is no clear trend in the amount of rainfall over time. Mean annual temperature is projected to increase by 1.1 to3.1°C in the 2060s, and 1.5 to 5.1°C in the 2090s (McSweeney *et al*, 2008). Under a single emissions scenario, the projected changes from different models span a range of up to 2.1°C.

The significant range between these climatic conditions highlights the uncertainty in future projections for climate change in Ethiopia. Clearly Ethiopia is highly vulnerable to current variability and there are also indications that climate change will increase rainfall variability which will likely increase losses from rain-fed agriculture (Belay and Getaneh, 2016; Arman, G. *et al*, 2016; Temesgen and Daniel, 2014). The ecosystems of the country as well as its community are highly exposed to climatic variability. Ethiopia is vulnerable to climatic variability owing to its low adaptive capacity accountable to low level of socioeconomic development, high population growth, inadequate infrastructure, lack of institutional capacity and high dependence on climate sensitive natural resource-based activities (Belay, 2016). Today climate change and variability are concerns of human being at global level. The recurrent droughts and floods threaten seriously the livelihood of billions of people who mainly their livelihood depend on agriculture. The global economy is adversely being influenced very frequently due to extreme events such as droughts and floods, cold and heat waves, forest fires, landslips etc. The loss of forest cover; which normally intercepts rainfall and allows it to be absorbed by the soil, causes precipitation to reach across the land eroding top soil and causes floods and droughts. Paradoxically, lack of trees also exacerbates drought in dry years by making the soil dry more quickly. A research conducted by World Bank in Morocco revealed that, due to reduced rainfall and higher temperatures, aridity increases and agricultural yields declines (World Bank, 2009).

Climate change has already significantly impacted agriculture and is expected to further impact directly and indirectly food production. Increase of mean temperature; changes in rain patterns; increased variability both in temperature and rain patterns; changes in water availability; the frequency and intensity of 'extreme events'; sea level rise and salinization; perturbations in ecosystems, all will have profound impacts on agriculture, forestry and fisheries (FAO , 2013). Rains fed crops are expected to be particularly affected. If irrigation water continues to be available in sufficient quantities, crop yields are expected to continue to increase in spite of climate change. However, availability of water for irrigation is uncertain (FAO, 2013). Broadly speaking, with everything else being equal, climate change may lead to an increase in both crop and livestock productivity in mid- to high latitudes (IPCC, 2007) and a decrease in tropical and subtropical areas. Among the most affected areas are economically vulnerable countries already food insecure and some important food exporting countries.

2.2. GHG Emission, Mitigation and Adaptation in agriculture of Ethiopia

2.2.1. Greenhouse Gas Emission in Ethiopia

While agriculture is the sector most vulnerable to climate change, it is also a major cause of climate change, directly accounting for about 14 percent of global greenhouse gas (GHG)emissions, and indirectly much more as agriculture is also the main driver of deforestation and land-use change responsible for Another 17 percent of global emissions (FAO , 2013).Even if emissions in all other sectors were eliminated by 2050, growth in agricultural emissions in a business-as-usual world with a near doubling in food production would perpetuate climate change. According to FAO (2016), Ethiopia's annual greenhouse gas (GHG) emissions were estimated at 150 Mt CO2 e in 2010, with 50 percent and 37 percent of these emissions resulting from the agricultural and forestry sectors respectively. In agriculture, livestock production accounted for more than 40 percent of the emissions, while in forestry the main culprit was deforestation for expansion of agricultural percent of forestry related emissions, followed by fuel wood consumption at 46 percent of forestry-related emissions. The major sources of GHG emissions within the agriculture sector of Ethiopia. The largest proportion of emissions results from enteric fermentation, followed by manure left on pasture, both of which are related to livestock production

2.2.2. Climate Change Mitigation and Agriculture

The overall efficiency of the agricultural sector and its resilience, adaptive capacity and its land, which accounted for over 50 potential for contributing to the mitigation of the effects of climate change and variations– can be enhanced by improving these constituent components. Indeed, by improving the efficiency of agricultural production, emissions can be reduced and sequestration capacity enhanced (Pretty *et al.*, 2011). There is much concern that the increasing concentration of greenhouse gases in general, and carbon dioxide in particular contributes to global warming by trapping long-wave radiation reflected from the earth's surface (FAO, 2013). Over the past 150 years, the amount of carbon in the atmosphere has increased by 30%. Most scientists believe there is a direct relationship between increased levels of carbon dioxide in the atmosphere and rising global temperatures (Stavins and Richards, 2005).

Mitigation is a human intervention to reduce the sources or enhance the sinks of greenhouse gases. Mitigation, together with adaptation to climate change, contributes to the objective expressed in Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC). The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner (IPCC, 2015). Ethiopia's per capita emission of less than 2 ton CO_2 Dioxide equivalent) is low compared to more than 10 tons in the EU and more than 20 tons in the US and Australia. The country's total emissions of around 150 Mt CO_2 e represent less than 0.3% of global emissions (FDRE, 2011). The agriculture sector is one of the major contributors of GHG (Green House Gas) emissions in Ethiopia through the crop, livestock and natural resources carbon footprints (like as a result of soil degradation and land use change from forest land to agricultural land). Ethiopia intends to limit its net GHG emissions in 2030 to 145 Mt CO_2e or lower. This would constitute a 255MtCO_2 e or 64% reduction from the Business As Usual emissions in2030, which would otherwise become 400Mt CO_2 e with BAU in the same year (Belay, 2016; Nathnael, 2017).

GHG emission has impacted the agriculture sector in a way that rainfall variability and associated yield reductions are estimated to cost Ethiopia around 38% of its potential grow threat and increase poverty by 25% (World Bank, 2006). Since the country's main-stay and/or economy are based on agriculture, climate change could negatively affect agriculture. Thus, it will ultimately reduce GDP by 3-10% by 2025 (Nathnael, 2017). Results show that warmer temperature is beneficial to livestock agriculture, while it is harmful to the Ethiopian economy from the crop agriculture point of view. Moreover, increasing/decreasing rainfall associated with climate change is damaging to both (crop and livestock) agricultural activities.

According to different studies, variety of mitigation strategies to immune level of emissions particularly from the agriculture sector (i.e., from crop, mainly livestock and natural resources) are drawn. Some of the identified mitigation strategies are: reducing expansion of cultivated land through agricultural intensification (increasing productivity by reducing Green House Gas (GHG) emission: conservation agriculture, compost, wise use of inorganic fertilizers, proper crop management); improving animal productivity through breeding; feedlots practice by smallholder farmers; improving feed and feeding management; diversification toward lower emitting animal species (small ruminants); mechanization; manure management; forestation/reforestation; agro forestry; soil and water conservation and land rehabilitation; and reducing rate of desertification (Belay,2016; Nathanael, 2017;Temesgen *et al*, 2009).

2.2.3. Climate Change Adaptation and Agriculture

Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007).By 2050, it is predicted that the global population will be over 9 billion people, increasing the demand for food and other agricultural products (FAO, 2013). At the same time, the world faces challenges such as land and water scarcity, increased urbanization, and climate change and volatility. Agricultural production remains the main source of income for most rural communities (about 86 percent of rural people - 2.5 billion), who depend on agriculture for their livelihood (World Bank, 2008). Improving adaptation of the agricultural sector to the adverse effects of climate change will be imperative for protecting and improving the livelihoods of the poor and ensuring food security. In practical terms, climate change adaptation requires more than simply maintaining the current levels of performance of the agricultural sector; it requires developing a set of robust and yet flexible responses that will improve the sector's performance even under the changing conditions brought about by climate change engenders (FAO, 2013).

According to FAO (2013), Main climate change exposure for densely populated highlands and poor areas like Himalayas, Andes, Central American highlands, Rift Valley, Ethiopian plateau, Southern Africa etc. are rainfall variability, droughts, and floods. They are vulnerable because, rain fed agriculture; marginal lands and poor soil moisture capacity are the very nature of the agricultural potential. The high prevalence of poverty, limited options, knowledge, social safety nets and resources drive to have low adaptive capacity. So, watershed management and on farm water storage for water conservation; integrated water resources management in river basins and investment in social infrastructures are advised to be a typical response option.

Adapting to climate change will entail adjustments and changes at every level from community to national and international. Communities must build their resilience, including adopting appropriate technologies while making the most of traditional knowledge, and diversifying their livelihoods to cope with current and future climate stress. Local coping strategies and traditional knowledge need to be used in integrated with government and local interventions. To enable effective adaptation measures, governments as well as nongovernment organizations, must consider integrating climate change in their planning and budgeting in all levels of decision making (Belay, 2016). Decisions on the type of adaptation are often made by individuals, groups within society, and organizations and governments on behalf of society. Some adaptation measures may be taken at individual level. Others like rainwater harvesting and investments, building dams, releasing new cultivars that are more drought resistance require collective actions. These time societies have inherent capacities to adapt to climate change and have developed different adaptation and mitigation strategies to combat climate change. They have developed knowledge, skills, technology, institutional arrangements and strategies that are important foundations for adapting to long-term climate change. Based on the type of economic activities and social networks societies can access local coping strategies against shocks. These highly differ among households and communities. Communities have always adapted to climate variations by making preparations based on their resources and knowledge accumulated through experience of past weather pattern. The adaptive measures that households use when faced with climate change could also differ in terms of their ease of implementation, equity effects, lag between implementation and effect, their cost of implications, compatibility with other programs, and agencies implementing measures (Admassie, 2008).

Climate adaptation measures will need to address systemic weaknesses and vulnerabilities that have historically impoverished those communities. Climate change will challenge the implementation of current and future development plans: adjustments and changes will be required at every level: community, national and international. A better understanding of the impacts, costs, changes and communities' perceptions of climate change, ongoing adaptation measures, and the decision-making process is important to inform policy makers and sector institutions aimed at promoting successful adaptation strategies for the country development program. Ethiopia will need to both mitigate the impacts of climate change, where possible, and adapt to the situation where it cannot (Yesuf *et al*, 2008).As impact will differ regionally, based on the bio-physical and socioeconomic situations within Ethiopia, the management of impacts will need to be defined for each region based on the analysis of current information and practices, the scope for variability within these systems and the possibility of alternative farming and livelihoods. Given the challenges outlined above, delivering an integrated response will require enhanced capacity for coordinating and leading 'joined-up' actions. New technologies, as well as current technologies used in new ways can support this response, but only if the appropriate enabling institutional and policy environment is in place to encourage joint working and embrace adaptive learning to take account of ongoing uncertainties or new opportunities (Tadege,2007).Studies in Ethiopia indicate that, the dominant adaptation methods practiced by Ethiopian crop producing farmers include: use of different crop varieties, tree planting, soil conservation, early and late planting, and irrigation adoption of mixed crop and livestock farming systems and changing planting dates (Temesgen *et al* 2009; Temesgen, 2014;Nathnael, 2017)

2.3. Concept of Climate Smart Agriculture Practices

Climate Smart Agriculture (CSA) as a concept was developed by the Food and Agriculture Organization (FAO, 2010). It is an approach to reorienting agricultural and cattle production to the new realities of climate change. It creates the technical, policy and investment conditions for achieving sustainable agricultural development and food security as climate change unfolds. It is composed of three main pillars:

- Sustainably increasing agricultural productivity and incomes ;
- Adapting and building resilience to climate change; and
- Reducing and/or removing GHG emissions where possible.

As presented in FAO, (2013), CSA is not a new agricultural system nor is it a new set of approaches. It is rather an approach, away to guide the needed changes in agricultural systems given the necessity to jointly address food security and climate change.CSA shares Sustainable Development and Green Economy objectives and guiding principles as it also aims for food security and preservation of the natural resources. FAO (2013) further notes that CSA takes into account the four dimensions of food security in terms of availability, accessibility, utilization and stability. Still, the entry point and the emphasis are on production, farmers, increasing productivity and income, and ensuring their stability. Climate-smart measures include proven techniques such as mulching, intercropping, integrated pest and disease management, minimum soil disturbance practices (MSD), crop rotation, agro forestry, integrated crop-livestock management, aquaculture, improved water management, better weather forecasting for farmers and innovative practices, such as early warning systems

(FAO, 2010; World Bank, 2011; 2012). It also entails embracing new technologies such as diversifying genetic traits of crops to help farmers edge against an uncertain climate and creating an enabling policy environment for adaptation (World Bank, 2011). Further still, CSA is concerned with post-harvest handling of crop produce along the value chain to minimize losses as well as the sustainable consumption patterns. In the absence of Climate Smart Agriculture, marginal areas may become less suited for arable farming as a result of land degradation through deforestation, soil erosion, repetitive tillage and overgrazing (World Bank, 2012). However, there is recognition that Climate Smart efforts must have at their heart smallholder farmer in the developing nation who is key to change across the entire agricultural system. Policy accompaniment and financing of the agricultural practices is yet another inclusion in the general scope of the original concept of CSA (FAO, 2013).

2.4.Opportunities and Challenges to Implement CSA Practices in Ethiopia

In spite of the potential benefits of the system especially to smallholder farmers who bear the brunt of the effects of climate, there is much skepticism about the capacity of CSA to mitigate the effects of climate by fostering resilience l*et al*one feed communities (Nciizah, and Wakindiki, 2015). Most of the household farmers in developing countries including Ethiopia are resource poor and they usually own degraded land (FAO, 2016). Also, a significant size of the farm lands is marginal with low yields. However, CSA would be the most appropriate system for such farmers since it uses locally available resources and does not rely on the use of external inputs (Magdoff, 2007).

As it is stated in Table 1, the current policies, strategies and laws related to climate change and CSA in Ethiopia are adequate. However, they are not adequately incorporated into extension guidelines and manuals (and the extension system as a whole) in a way that the great majority of the rural farming population could understand and participate in their implementation. For this reason adoption of practices such as conservation agriculture remains relatively low. The promotion of integrated watershed management to improve agricultural productivity, with major emphasis on avoiding open and uncontrolled grazing, sufficient resource endowment in the form of projects and programs like AGP, SLM, PSNP and others and the availability of adequate numbers of extension and development agents at grassroots level provide a good opportunity for large-scale implementation and promotion of climate smart practices. Lack of skilled human resources on climate change adaptation and mitigation at all levels, weak coordination mechanisms at federal and regional levels, lack of mechanisms to bring together and coordinate stakeholders involved in different forms of CSA technology promotion, the dominant nature of conventional agricultural practices like frequent plowing and removal and burning of crop residues and the open grazing characterization of livestock husbandry are key challenges to implement CSA in Ethiopia (FAO, 2016).

Therefore, analyzing the untapped opportunities and key challenges to upscale CSA is demanding for policy makers and practitioners to moveforward.CSA requires changes in farming households' attitude, strategies and planning, as well as changes in the usual timing of agricultural practices. All such expected changes without appropriate institutional structures, supporting national policies and strategies may seem irresistible to the adverse impact of climate change by smallholder farmers (FAO, 2013). Farmers need policies that remove obstacles to implementing climate smart agriculture, and create synergies with alternative technologies and practices. Policies and strategies should recognize and support proven technologies for carbon sequestration in such like climate smart crop production practices. Considerable policy support and capacity enhancement is needed for climate risk management including insurance and safety nets, as well as improved access to weather information adapted to farmers' needs. Ways and opportunities need to be found that strengthen synergies in the implementation of climate smart agriculture and food security programs and initiatives.

At present, there is willingness and commitment from the Ethiopian government to reduce poverty and ensure food security while addressing climate change. The government has developed policies and strategies that are pertinent to ensure food security as well as address climate change. The government has put in place a number of policies, strategies and institutions that are designed to support climate change adaptation and mitigation and sustainable development as a whole. Moreover, Ethiopia has signed and/or ratified many of the international conventions and protocols related to climate change and land degradation including the United Nations Framework Convention on Climate Change (1994), the Convention on Biological Diversity (CBD) and the United Nations Convention to Combat Desertification (UNCCD) (FAO, 2016; Belay, 2016).

Policies, laws and strategies relevant to climate change in Ethiopia include the Climate Resilient Green Economy Strategy (2011), National Adaptation Program of Action (NAPA), Ethiopian Program 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 Environmental Policy of Ethiopia (1997).The Climate Resilient Green Economy Strategy known as CRGE was developed in 2011 and launched at the 17th Conference of the Parties to the United Nations Framework Convention on Climate Change in Durban in 2011 (UNDP, 2011). The strategy takes an economy-wide approach to greenhouse gas reduction. According to the strategy, Ethiopia aims to achieve carbon-neutral middle-income status before 2025. The strategy is based on four pillars, of which the first two pillars are mainly related to CSA. These are: "Improving crop and livestock production practices 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" (FDRE, 2011).

Table1. Summary of key policies, laws and strategies relevant to CSA practices in Ethiopia.

Policy, law and strategy	Year	Intention or goal
Articles 43 and 44 of the Ethiopian constitution	1995	Government and citizens shall have a duty to protect the environment. The design and implementation of programs and projects shall not damage or destroy the environment.
Environmental Policy of Ethiopia	1997	Promote sustainable social and economic development through the sound management and use of natural, human-made and cultural resources and the environment as a whole so as to meet the needs of the present generation without compromising the ability of future generations to meet their own needs'
Environmental Impact Assessment	2002	Ensure that the environmental implications are taken into account before any major development projects are made
National Adaptation Program of Action(NAPA)	2007	The NAPA represented the first step in coordinating adaptation activities across government sectors
TheComprehensiveAfricaAgricultureDevelopmentProgram(CAADP)Compact	2009	One of the pillars of CAADP is extending the area under sustainable land management and reliable water control systems. CAADP has been endorsed by the African Heads of State and Government as a framework for restoration of agriculture growth, food security and rural development in Africa.
Growth and Transformation Plan(GTP I and II)	2010-2015 /2016 -2020	The GTP recognizes that the environment is a vital pillar of sustainable development. The GTP addresses climate change as a crosscutting issue under the strategic priority of environment and climate change.
Agriculture Sector Program of Plan on Adaptation to Climate Change/APACC	2011	The Agriculture Sector Climate Change Adaptation Plan.
Ethiopian Program 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

(Adapted from: FDRE, 1995; FDRE, 2011; FAO, 2016)

2.5. Some common Climate Smart Agricultural practices in Ethiopia

As fundamental to livelihoods and food security improvement program, both traditional and innovative agricultural practices are conducted in Ethiopia. Currently, agricultural development activities carried out in the country are supported by a number of policies, strategies and institutions. Of the numerous agricultural development activities conducted, CSA practices mentioned in elaborative manner are considered important in addressing issues related to climate change and are contributing to climate change adaptation and mitigation (Table 1). Such agricultural practices in Ethiopia include integrated watershed management, integrated soil fertility management, sustainable land management, conservation agriculture, agro forestry, crop residue management, composting, promotion of improved livestock feed and rangeland management (FAO, 2016).

Ethiopia is one of the countries heavily affected by land degradation, and addressing this problem is a major priority task for the country. In Ethiopia integrated watershed management is conducted through various projects and programs, which include the Sustainable Land Management Programs (SLMP1 and SLMP2), Managing Environmental Resources to Enable Transitions to more Sustainable Livelihoods (MERET) project, Productive Safety Nets Programs-Public Works (PSNP-PW) and numerous NGOs. Studies indicate that land and crop production and productivity have 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 (Branca *et al* 2011). It is reported that soil organic matter content sequestration can be achieved by implementing sustainable land management practices that add high amounts of biomass to the soil, cause minimal soil disturbance, conserve soil and water, improve soil structure and enhance activity and species diversity of soil fauna. About 12, 500 households who adopted conservation agriculture, resulting in a 60% increase in crop yields (FAO, 2016). Also yields of crops from composted plots were 3 - 5 times higher than those treated only with chemicals (Branca *et al*, 2011; FAO, 2016; Nciizah, and Wakindiki, 2015).

Table: 2. Some Common CSA Practices in Ethiopia

CSA practice	**Components**	**Why it is climate smart?**
Conservation agriculture	Reduced tillage, Crop residue management- mulching, intercropping, Crop rotation/intercropping with cereals and	Carbon sequestration, Reduce existing emissions, Resilience to dry and hot spells
Integrated soil fertility management	Compost and manure management, including green manure, Efficient fertilizer application techniques (time,	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
Agro forestry	Tree-based conservation agriculture Practiced both traditionally and as improved practice, Farmer-managed natural regeneration	Trees store large quantities of CO 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	Ensuring food security, Resilience to weather variability, Alternative livelihoods and improved incomes
Improved livestock feed and feeding practices	Reduced open grazing/zero grazing, Forage development and rangeland management, Feed improvement, Livestock breed improvement and	Improved livestock productivity GHG reduction CH_4 reduction
Other	*In situ* water conservation/harvesting, Early-warning systems and improved weather information, Support to alternative energy fuel efficient stoves, bio fuels, Crop and livestock insurance, Livelihoods diversification (apiculture, aquaculture), Post-harvest technologies (agro processing, storage)	Resilience of agriculture Improved incomes Reduced emissions Reduced deforestation Reduced climate risk

(Adapted from FAO, 2016)

2.6. Climate Smart Crop Production Practices

Environmental stresses have always had an impact on crop production, and farmers have always looked for ways to manage these stresses. Climatic conditions that influence crop systems include: rain quantity and distribution, and consequently water availability; extreme events, such as floods and droughts; higher temperatures; and shifting seasons (FAO, 2013).At the field level, there are a wide range of agricultural practices and approaches that are currently available that can contribute to increased production while still focusing on environmental sustainability. Considering the ecological, social, policy and economic dimensions of a specific location, CSA practices can contribute to climate-smart crop production i.e. approaches to adapt to, and contribute to, the mitigation of climate change (FAO, 2016).

Some of CSA approaches and practices that contribute to climate change adaptation are: ecosystem-based approaches; conservation agriculture; integrated nutrient and soil management; mulch cropping; cover cropping; alterations in cropping patterns and rotations; crop diversification; using high quality seeds and planting materials of adapted varieties; integrated pest management; integrated weed management; grasslands management; water and irrigation management; landscape-level pollination management; organic agriculture; and land fragmentation (riparian areas, forest land within the agricultural landscape)(FAO,2013b).

On the other FAO document there are also many different approaches and practices for sustainable crop production that can contribute to climate change mitigation. Some of the widely practiced are : conservation agriculture; soil compaction management; improved farming systems with several crop rotations; crop diversification; promotion of legumes in crop rotations; growing cover crops; mulch cropping; restoration of cultivated peaty soils and degraded lands; soil management practices that reduce fertilizer use (e.g. urea deep placement); integrated nutrient management; growing nutrient-use efficient crop varieties; integrated crop and livestock systems; dedicated energy crops to replace fossil fuel use; emission control and reduction (combustion engines, animal waste); improved rice cultivation techniques; water management/conservation, irrigation, water table management; and agro forestry (FAO , 2016).

3. MATERIAL AND METHODS

3.1. Study Area Description

The study was conducted in Shashamene district of Oromia Regional State, south eastern Ethiopia, located at $40^{0}28'$ to $40^{0}50'$E and 08^{0} $10'$ to 08^{0} $43'$N, located about 250 km south of Addis Ababa. According to Shashamane district's Finance and Economic development office data, the district is composed of 37 rural Peasant Association (PA) covering a total area of about 58,011.7 hectares. The district shares common bounders with Shalla district in the west, Nagele Arsi district in the North and north east, Kofale district in the south east and Wondo district, and southern people nation and nationalities regional state in the south.

Major crops grown in the area includes Maize, Wheat, Barley, Tef, Finger Millet, Haricot beans, Potato and Sorghum. Additionally, the major livestock reared in the district are cattle, goats, sheep, poultry and donkey. Currently the district is the home of 144,775 males, 148,233 females totally 293,008 people. The total household population of the district is about 45, 166 with 35,783 male household headed and 9,383 female house hold headed. The largest ethnic groups in districts are the Oromo (74.11%) and all other ethnic groups made up (25.89%) of the population. With regard to religion, almost 86.53% of the population in the district is believers of; Muslim and Ethiopian Orthodox Tewahodo Christianity, while Protestants constitute about 13.47%.

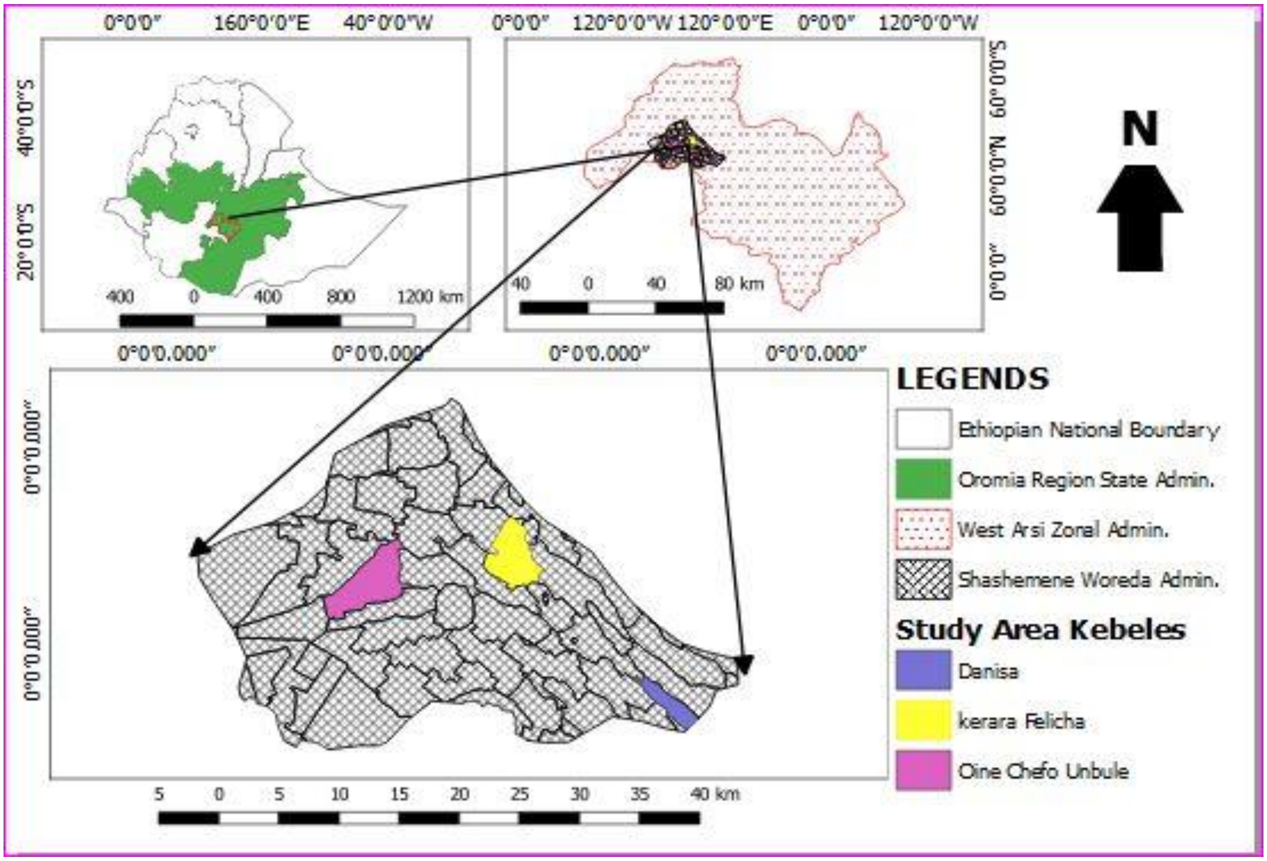


Figure: 1. Map of the study Area

Land use

With regard to land use pattern, cultivated land covers the largest share, (72.14 %) while forest land is the second largest land use pattern that covers (0.81%). About (0.52 %) grass land,(0.02%) shrub land, Bushes land (0.03%), swamp area (0.02%), of the total 58,011.7 ha of the woredas' land area (CSA 2010).

Soil

According to FAO/UNESCO classification, the soil resources of the district are classified into Chromic Camisoles (35%), Enteric Fluvial soils (10%), Luvisols (15%), Enteric Nit sols (25%), and Orphic solon hacks (15%) with the rest being composed of swamps and marshes, rocks, stones and sand.

3.1.1. Agroecology and climate

Shashemene is divided in to three major agro- climatic areas mainly based on variation in altitude. It has three agro ecological zones with different proportions as Weina dega, Kolla and the Dega covering 75 %, 15 % and 10 % of the total area coverage of the district respectively. The most parts of Shashamene district is aggradations plain and rift valley with mountains having an altitude range of 1500 -2300masl.

The mean annual temperature ranges of the woreda are 12-27^{0}C to 11-21^{0}C, in the lowlands and highlands respectively. This great variation of in temperature provides wide opportunities for the production of different types of crops range from warm to cool thermal district. The rainfall pattern is with bi-modal tendency having small rainy season during the months of April and May, while the main rainy season is during the months of July, August and September. Areas that have over 2722 m.a.s.1 elevation receive high and fair distribution of annual rainfall (700-1000mm). But the vast areas of the district (below 2722m.a.s. l) have erratic and small annual rainfall varies between 550 and 700mm.

3.1.2.Natural Resource

Vegetation cover

The major type of land covers including forest Afro alpine health vegetation, wood, shrubs, grass, swampy, water , salt flatland rock

Forest: It includes the dense mixed high forest distributed to high dense coniferous high forest areas. Forest areas are confined to highland of the district

Wood land: It includes wooded grassland, open and dense woodland. The woodland was characterized by discontinuous canopy and smaller trees than the high forest area. Wood land can be defined as a continuous stand of trees with a crown density of 10 to 90 % mature trees are usually single storied although there may be layered under stories of immature trees, and of bushes, shrubs and grasses.

Shrub/Bush Land: Shrubs are a multi- stemmed woody plant in which most of steam very close to the ground, in general, less than 5m high but can be founded much higher in favorable environments. They are often intermixed with the grasses and the moderately cultivated land areas. The main activities of these areas are pastoral livestock grazing and browning. Shrub and Bush areas are confined to large portion of district lowland

Water resource: The majority of the Shashemene district Rivers that originated from the South east highland area and some of major perennial rivers include Dedeba, Dedeba Tina, Melka Laftu, and Melka Oda. The major characters of the district Rivers first they start from the area of sufficient rainfall and empties to lake crossing areas that have scarcity of rainfall. Second character was the economic values of them are significant in the areas of sufficient rainfall. Melka Laftu is currently used for small scale irrigation and Dedeba also used for irrigation at Ethiopia Adventist college compound. The rest Rivers are obviously used for social purposes like drinking, washing and cattle watering.

3.2. Research Design and Methodology

3.2.1. Site selection

The study was conducted in Shashemene districts, West Arsi Zone of Oromia Regional State. The study implemented purposeful multistage stratified sampling method. In the first stage, the district was purposefully selected due to the fact that in these areas the environment has been degraded largely, rainfed and the occurrence of climate change that affect agricultural crop production frequently. In the second stage, the 37 kebeles of the woreda were stratified into three categories based on agro ecological zones. In the third stage 3 kebele administrations (KAs) namely, Fillicha, Danisa and Oinecefo Umbure were purposefully selected among a three agro ecological strata based on socio economic, infrastructural accessibility, and agro- ecology and other physical factors status of the kebeles to carry out the study. In the last stage, representative household will randomly selected for household survey from the selected three kebele administration.

3.2.2.Sampling techniques and sample size determination

The sample size was administered through (Yemane, 1967) sample size determination formula as follows; $n = \frac{3697}{1+3697(0.05)^2} = 361$

Table: 3 Sample size distribution of the study area

No	Name of Kebele Administration	Total Household			Sample Household			Agro ecology
		Male	Female	Total	Male	Female	Total	
1.	Oine ChafoUmbure	1360	319	1679	Random	Random	160	Low land
2.	Karara Filicha	835	449	1284	Random	Random	128	Mid land
3.	Danisa	555	179	734	Random	Random	73	High land
	Total	2750	947	3697	Random	Random	361	

Source (Shashemene Woreda Land Administration, 2019)

3.1. Data Collection

The study had gathered both primary and secondary data. The primary data was obtained by using a survey questionnaire, Focus group discussion; key informant interviews and transect walking. The secondary data sources such as CSA and NMA database, reports, proclamations and other documents were used to reinforce the data collected from the primary sources.

3.1.1.Primary data sources

Key informant interview

About 11 key informant interviews were also made in which two experts from Shashemene woreda agricultural and natural resource office, three agricultural development agents from the sample kebeles and six selected female and male headed households farmers from sample kebeles were interviewed to collect primary information about awareness , challenges and adaptation of CSA crop production practices among the rural community.

Focused group discussion

The purpose of the focus group discussions was to generate in depth information on some of the survey findings and other issues that may not have been adequately captured by the structured questionnaire survey.

The FGD was employed to collect first hand information on climate variability and the existing, practices, challenges and implementation of CSA crop production practices. Focus group discussion participants were purposively selected in order to represent different social groups and years of experience on climate smart agricultural practices of their kebeles. Accordingly, three focus group discussions which consist of 6-12 individuals were conducted across the sample kebeles.

Household survey

The prepared Questionnaires were distributed for 361 sample household farmers of the study woreda who are living in three purposefully selected kebeles, in order to assess: the patterns and trends of climate variability, perception of farmers in CSA practices and significant factors in adapting CSA practices particularly in crop production context.

Observation

Observing the situation in the selected kebele administration was made by the researcher to identify the farmer's landmarks, soil and water management patterns, agro forestry practices , socio-economic indicators and resource endowments in order to validate information received through key informant interview and/or focus group discussions.

3.1.2. Secondary data source

Secondary data were collected from different relevant available sources of information such as published and unpublished documents. Long term rainfall and temperature data were accessed from National Meteorology agency to evaluate climatic trends in the study area. Other relevant data were collected from government offices such as; Shashemene district Agriculture and Natural resource office, Finance and economic development office and land administration office and other governmental offices like central statistical agency (CSA).

3.2. Method of data analysis

3.2.1. Climate Trend Analysis

i. **Trend Analysis**: - Regression trend analysis was employed to evaluate long term rainfall and temperature trends/ changes. The regression equation that describes a simple linear type regression relationship in a population was expressed as:

$$Y_i = \alpha + \beta X_i + \varepsilon_i \qquad \text{.. (1)}$$

ii. **Coefficient of determination** (R^2) value which shows the degree of relationship between dependent (Y) variable (rainfall and temperature) and the independent time series (X), using the following equation:

$$R^2 = \frac{\left(\sum XY - \frac{\sum X \sum Y}{n}\right)^2}{\left(\sum X^2 - \frac{(\sum X)^2}{n}\right)\left(\sum Y^2 - \frac{(\sum Y)^2}{n}\right)} \qquad \text{.. (2)}$$

iii. **Coefficient of variability** (CV %) will be calculated to estimate the extent of variability especially in annual and seasonal rainfall.

$$CV = \frac{SD}{\bar{X}} * 100 \qquad \text{................3}$$

iv. **Standard Precipitation Index (SPI)**

The Standardized Precipitation Index by McKee *et al.*, (1993) is a probability index which described the representation of abnormal wetness and dryness and compares precipitation with its multiyear average. Determining the probability density function which described long time series of precipitation is the first step of SPI method. The series could be modified for much different time duration but typically series used for total precipitation is 1, 2, 3, 6, 9, 12, 24 months. The cumulative probability of an observed precipitation amount could be computed after determined the function of probability density. Then, inverse normal of the Gaussian function applied to the cumulative probability (mean zero and variance one) (Guttman, 1999).

Drought monitoring could be explained by the SPI time series. Positive SPI values indicate a wetter than the typical period (accumulated precipitation is greater than median), and negative SPI values are represented dryer period with less precipitation than normal. In order to consider and evaluate the impact of the climate change using Standardized Precipitation Index (SPI) method as the evidence of climate anomaly, this study also used SPI to describe agricultural drought conditions.

Agricultural drought is a situation when rainfall and soil moisture are inadequate during the crop growing season to support healthy crop growth to maturity, causing crop stress and wilting. The flexibility of time scale choosing is an advantage of SPI calculation. To explore correlations of drought with the areas the study focused on SPI-9. The time has decided because it is suitable times to describe agricultural drought as the study purpose to climate smart crop production and will be used to quantify the precipitation deficit for a given scale as follows;

$$\text{SPI}=\frac{X-\bar{X}}{SD} \quad \ldots\ldots 4$$

3.2.2. Climate change Perception and adaptation of Climate Smart Crop Production Practices by smallholder farmers

The researcher hypothesis at least one of the following factors can determine the small holder farmer's climate change perception and climate smart crop production practices in the Shashemene district to decide the fate of crop production in the district.

Table: 4 Expected sign of hypothesized variables of the study

Factors	Expected Sign	Remark
Age house hold	±	Either of one
Gender	±	
Family size	±	
Education	+	
Farm size	+	
Farm distance from market	+	
Livestock asset	+	
Local organization membership	+	
Access to credit	+	
Off-farm income	+	
Access to media and weather forecasting	+	
Training and Extension service	+	

v. Statistical model analysis

Therefore, the study were going to used descriptive statistical analysis including frequency distribution, percentage, mean and standard deviation(SD) for socio economic and institutional data and also, regression analysis using logit model to identify determinant factors that influence the implementation of CSA practices by rural famers using computer software called (Stata version 16.) by using the data collected with questionnaires from the selected household farmers depending on the hypothesized factors. Also, specific characteristics of the variables and results will present in tables, graphs and charts.

Since the two computing models commonly use in the like adaptation studies are the probit and logit models. The models are popular statistical techniques in which the probability of a dichotomous outcome (such as practicing or non-practicing) was related to a set of explanatory variables that are expected to influence the outcome. But the results obtained from the two models are very similar since the normal and logistic distributions from which the models are derived are very similar. There is no compelling reason to choose one over the other. In practice many researchers choose the logit model because of its comparative mathematical simplicity (Gujarati and porter, 2009).

Logistic regression also referred to as logit model has no assumptions about the independent variables: they do not have to be normally distributed, linearly related or of equal variance within each group (Tabachnick BG, 2007). Due to its computational simplicity and other statistical advantage logit MNL model will be employed in this study. Following (Gujarati and porter, 2009) the models can be specified as:

$P_i = E(Y_i = 1/X_i) = F(\beta_0+\beta_i X_i)$ …………………………………………………………… (5)

$= \frac{1}{1 + e^{-(\beta_0+\beta_i X_i)}}$

$= \frac{1}{1 + e^{-(z_i)}}$=, where $z_i = \beta + \beta x$

$= \frac{e^{-(z_i)}}{1 + e^{-(z_i)}}$……… is the cumulative logistic distribution function…………………… (6)

Where; $P_i = P\ (Y= 1)$ is the probability that the farmers adopt CSA practices

X_i = are different factors that affect farmer's adoption decision

β_0 = is the constant term.

β_i' s = are the coefficient of parameters.

In the estimation of the model, the probability of non – adoption is given by:

$1 - P_i = \frac{1}{1 + e^{-(z_i)}}$ ………………………………………………………………… (7)

And the odd ratio which tells the ratio of the probability of the farmer will adopt CSA practices to the probability the farmer will not adopt the practices can be written as:–

$\frac{P_i}{1+P_i} = \frac{1+e^{Z_i}1}{1+e^{-Z_i}} =$ ……………………………………………………………… (8)

Hence,

$L_i = \ln [\frac{P_i}{1+P_i}] = Z_i = \beta + \beta$ x, Where, L_i is the log of the odd ratio………………… (9)

Also; $Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_i X_i + e_i$... (10)

Taking the natural logarithms of the odds ratio of equation (4) will result in what is called the logit model as indicated below.

$\ln [\frac{P_i}{1+P_i}] = \ln [e^{\beta_0} + \sum_{i=1}^{n} \beta \text{ Xi}] = Z_i = \beta_0 + \sum \beta X + e_i$..(11)

(e_i is the error term with zero mean and constant variance.)In this study the logical function (11) is applied to model the independent variables. Where; Z_i denotes the probability of the i_{th} farmer to adopt the CSA practices. β predicts the log odds of the dependent variable.

4. RESULTS AND DISCUSSION

4.1. Climate Variability in the Districts

Long term climate especially rainfall and temperature data of the study area were analyzed to evaluate the trends and variabilities observed as well as to discover if smallholder farmers' perceptions on climate change and variability match with actual, annual rainfall and temperature conditions and discussed below.

4.1.1. Temperature Trends

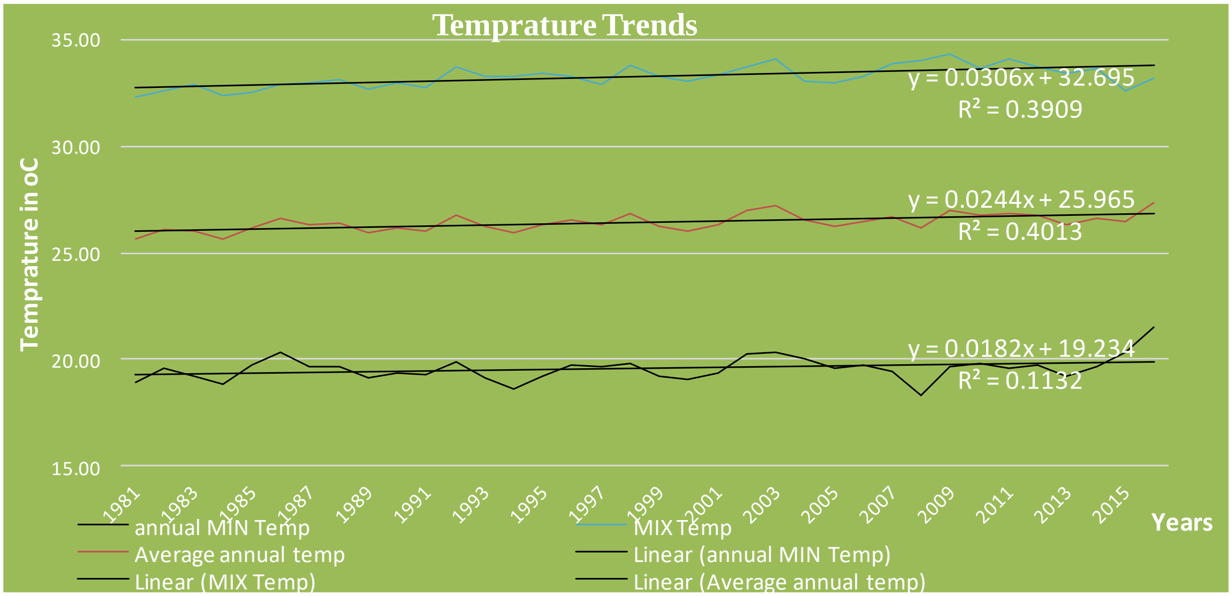
The mean annual temperatures during the last 36 years in the study area was found to be 26.42 ^{0}C, while the annual mean minimum and maximum temperatures were 19.57°C and 33.26 ^{0}C, respectively. The regression trend analysis of the 36 years' data of the study area for the annual minimum and maximum temperatures were found to be 0.018 and 0.031^{0}C of annual increase (Table 5). The contribution of time series to the annual maximum was 39.09% (Figure 2).

Table: 5 Regression coefficient of climate data of the Woreda

Time series	Coefficient of Determination	Std/ Err.	T	P>t	[95% Conf. Interval]	
Annual RF						
Year	-1.554	2.801	-0.550	0.583	-7.246	4.138
_cons	3999.847	5597.372	0.710	0.480	-	15375 .080
Annual Minimum Temp						
Year	0.018	0.009	2.080	0.045	0.000	0.036
_cons	-16.815	17.463	-0.960	0.342	-52.304	18.673
Annual Maximum Temp						
Year	0.031	0.007	4.670	0.000	0.017	0.044
_cons	-27.868	13.087	-2.130	0.041	-54.464	-1.271
Average temp						
Year	0.024	0.005	4.770	0.000	0.014	0.035
_cons	-22.342	10.213	-2.190	0.036	-43.096	-1.587

Source (NMA, 2020)

The result showed that relatively low variability was observed in the annual minimum temperature (CV = 2.91%) than the annual maximum temperature (CV = 1.55%). The rate of the increasing trend of 0.031^{0}C per year in annual maximum temperatures obtained in this study exceeded the findings reported by NMSA (2001) on the increasing trends of mean annual temperature by 0.010 °C per year during the past 50 years in Ethiopia. However, it is below the report of Tadege, (2007) who indicated the average annual mean minimum temperature increase over the country as 0.037°C per year. The results also corroborated with the findings reported by the IPCC (2001) showing that the mean temperature of the world has increased at about 0.5°C during the twentieth century. This research further indicated the significant increasing trend of temperature in the study areas in day time than in night, and agreed with the recent trends of global warming as reported by the IPCC (2013). Increased daytime temperature leads to heat stress to crop, which affect crop productivity and quality. On the other hand, night-time warming (minimum temperature) could affect quality and quantity of crop production in the study area. According to Wan *et al.* (2009), night-time warming increases the rate of respiration while it decreases the rate of photosynthesis and results in a low-level total non-structural carbohydrate cycle, minerals and protein as compared to the built-up of structural carbon through the accelerated growth of plants. Hence, in this study, the rising trend of both maximum and minimum temperatures may have a negative effect on crop production quality and quantity and livestock production and productivity.



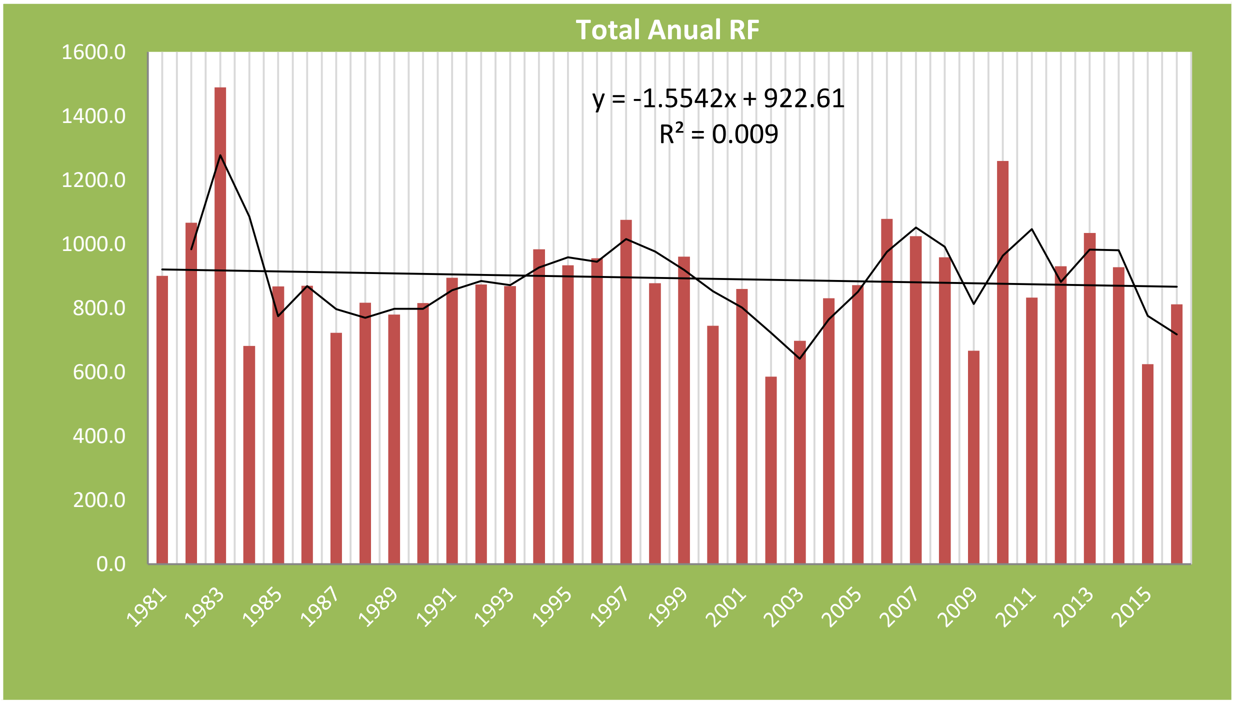
Source (NMA, 2020)

Figure 2 mean annual maximum and minimum temperature trend from 1981 to 2016.

4.1.2. Rainfall Trends

The annual rainfall results showed that, the average total rainfall from 1981–2016 was 893.86 mm in the study area, while the minimum and maximum rainfalls during the observation periods were 585.4mm in 2002 and 1489.7mm in 1983 (Table 6).

The regression coefficient results indicated that the long-term declining of rainfall trend (-1.55 mm per year) was not found to be statistically significant (Table 5). The result is in line with the studies by Woldeamlak and Conway (2007) in north-western Ethiopia, Seleshi and Zanke (2004) in central, northern and north-western Ethiopia, Conway *et al.* (2004) in the central Ethiopian highlands reported non-significant and unclear trends of annual rainfall.



Source (NMA, 2020)

Figure 3 Rain fall trend from 1981 to 2016.

i) **Coefficient of variability** (CV %)

The extent of long term rainfall variability in the study area indicated with CV value of 19.35 reveals that the rainfall is consistent and less variable despite a slight decreasing trend (Table 6). According to Hare (2003), CV is used to classify the degree of variability of rainfall events as less variable (CV < 20), moderatly variable (20 < CV <30), and highly variable (CV >30). Similarly, Muluken Mekuria (2017) found, the coefficient of variation of annual rainfall for the Amibara and Gewane districts as less variabile despite lower in amount of annual rainfall (CV < 20) as compared to seasonal rainfall variability.

Table: 6 Summery statics of RF data of the Woreda

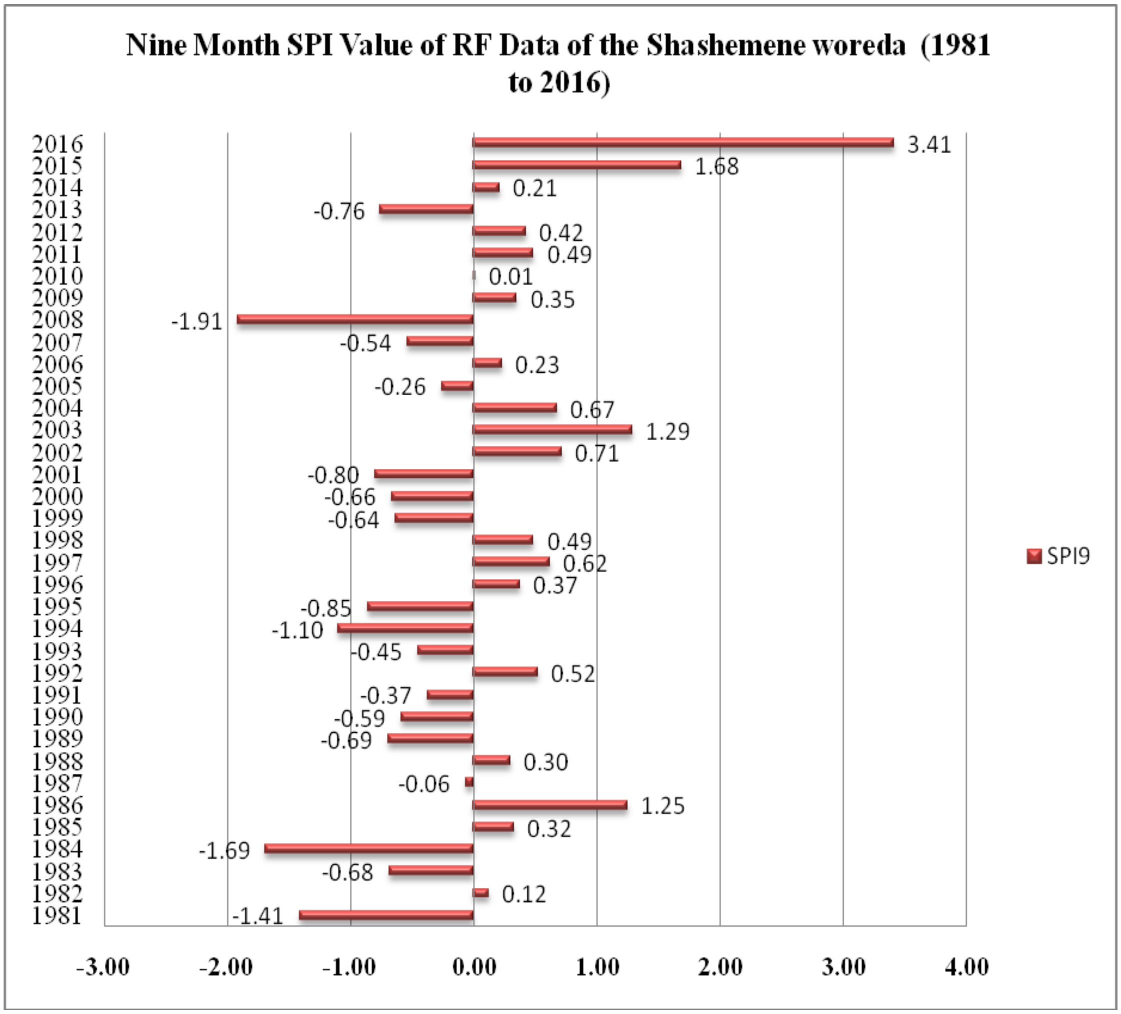
Level of Variables	N	Min	Year Observed	Max	Year Observed	Mean	CV%	Std. Deviation
Annual RF	36	585.4	2002	1489.7	1983	893.86	19.34	172.84
Annual MIN Temp	36	18.34	2008	21.55	2016	19.57	2.91	0.57
Annual MAX Temp	36	32.29	1981	34.36	2009	33.26	1.55	0.52
Average annual temp	36	25.61	1981	27.39	2016	26.42	1.54	0.41

Source (NMA, 2020)

ii) Standard Precipitation Index (SPI)

The SPI values were calculated on the basis of long-term series of 9-month precipitation within 36 years (1981-2016) in Shashemene woreda. As a result, the major drought years were identified as 1981, 1984 and 2008 with SPI value of -1.4,-1.7 and -1.9 respectively in the study area (Figure 4) and the wet periods were 1986, 2003, 2015 and 2016 with 1.2, 1.2, 1.6 and 3.4 SPI values respectively. As indicated in the Figure 3 below drought and flood occurs three to four times with the extent of moderate to severe drought and wet conditions in the 36 years. Results of SPI also indicated that, severe and extreme droughts in the study area occurred in 1984 and 2008, respectively, while moderate droughts occurred in 1981 and 1994 (figure 4).

On the other hand, extreme wet seasons were recorded in 2015 and 2016, while two moderatly wet seasons occurred in 1985 and 2003 (figure 4). This is supported by Seleshi and Zanke (2004) who showed that the most devastating disaster that occurred in Ethiopia was the 1984 famine due to the failure of the long rainfall season (June to September), which caused a decline of the GDP by 97% and agricultural products by 21%. Due to its widespread coverage across the region, much has been said for the 1984 famine in Ethiopia. However, for this particular study area, the analysis showed that the rainfall recovered and slightly progressed at 1985.



Source (NMA, 2020)

Figure: 4 Nine months SPI of the study area.

4.2. Perception of Climate change and CSA Crop Production Practices

4.2.1. Socio Economic Characteristics of respondents

From a total of 361 respondents included in the survey, 80% were male and the rest 20 % were female. The ages of household head respondents ranged from 25 to 70 years. Around

65% of the respondents were below 50 years and about 35% were above 50. Marital statuses of household respondents were; 80% married, 16% widowed and 4% divorced. From the total respondents around 51% completed1st Cycle educated, 6%, high school education, 2 % Collage and above, while 41% of the household heads didn't pass through formal educated (Table: 7). Average family size of the respondents was 5 and average land holding 1.4 ha per household.

Table: 7 Continues variables summary statistics of Respondents

Continues Variables	Average	Maximum	Minimum
Age house hold (years)	47.1	70.0	25.0
Family size (Person)	4.9	9.0	1.0
Farm size (ha)	1.4	7.0	0.5
Farm distance from market(in Min)	38.6	90.0	10.0

Source (own survey, 2020)

4.2.2. Farmers' Perception on Climate Change and its Impact

To harmonize the results obtained from climatic trends analysis with the perceptions of the farming community socio economic data were collected from the study area. The data provided information on how households perceive about climate variability, as well as climate smart crop production practices used to adapt and mitigate the effect of climate variability and change.

Results of the study showed that, 90% of the respondent farmers in the study area are well aware about the climate variability and change. In this regard, 80% of them perceive the existence of variation in temperature, while 87% sense variation in precipitation (Table 8). Causes of climate variability were also identified to be related to human's social and economic activities on the natural environment in the pursuit of achieving economic objectives at local, regional and/or global levels. Accordingly, only 21.6% of the respondents believe CSA CpP application as a basic solution to the impacts of changing climate.

Table: 8 Categorical variables summary statistics of Respondents

Variables		**Frequency**	**Percent**
Education	Not educated	150	41.6
	1st Cycle educated	183	50.7
	2nd Cycle educated	22	6.1
	Collage and above	6	1.7
Livestock asset		232	64.1
Local organization membership		342	94.5
Access to credit		290	80.1
Farmer income status		358	98.9
Access to media and weather forecasting		276	76.2
Training and Extension service		307	84.8
farmers' view on rainfall variability		314	86.7
farmers' view on temp variability		289	79.8
Feeling to CC		325	89.8
Knowing CSA CpP		78	21.6

Source (own survey, 2020)

The focus group discussions in the current study exposed the destruction level of natural resource base, which includes deforestation especially for charcoal burning and expansion of agricultural land has led to climate variability in the areas. In addition, poor farming practices such as burning of crop residue, cultivation of marginal lands such as hills and marshlands and ridging along the slopes in upland areas were also the major causes to climate variability.

The other point raised was factors influencing farmers view toward climate change including variables such as; Gender, Age of household, Education, Local organization membership, Access to media and weather forecast, Training and Extension service, Farmers view on rain fall variability and Farmers view on temperature variability were hypothesized as influencing factors on the farmers' perceptions on climate change (Table 9).

As analyzed in the logit model, five variables have significantly positive influence on climate change perceptions of smallholder farmers. In this regard, 96.7% of the respondents believe that Gender has significant influence on farmer's perception in which male headed households get more information than females. This result is in line with the argument that male-headed households are often considered to be more likely to get information about new technologies, climate and take risky businesses than female-headed households (Asefa and Berhanu, 2008).

Similarly, 77.5% of them think that, as access to media and weather forecast increases, the probability of perceiving about climate change will increase. It is also accepted by the respondent farmers that, Training and Extension service influences by 102.5 times on their climate change perception than those with no access to extension services. In technology adoption studies, social capital plays a significant role (Isham, 2002), in information exchange, and hence, it was hypothesized that more social capital is associated with higher level of perception of climate change.

Table: 9 Logit model output on farmers climate change perception

Feeling to CC	**Coef.**	**Std. Err.**	**Z**	**P>z**	**[95% Conf.**	**Interval]**
Gender	0.967	0.347	2.790	0.005	0.288	1.647
Age of household	0.004	0.014	0.280	0.778	-0.024	0.031
Education	0.301	0.244	1.230	0.217	-0.177	0.779
Local organization membership	0.966	0.641	1.510	0.132	-0.291	2.223
Access to media and weather forecast	0.775	0.335	2.310	0.021	0.117	1.433
Training and Extension service	1.025	0.389	2.640	0.008	0.263	1.786
Farmers view on rainfall variability	-0.210	0.468	-0.450	0.654	-1.126	0.707
Farmers view on temp. variability	1.713	0.322	5.310	0.000	1.081	2.344
_cons	-2.999	1.015	-2.950	0.003	-4.988	-1.009

Source (Own survey, 2020)

4.2.3. Farmers' perceptions toward climate smart crop production practices

In addition to their socioeconomic status that can affect their perception level, sampled households generally confirmed the importance of climate smart agricultural crop production practices in their area (Table 10). They were then asked which of the climate smart agricultural crop production practices they consider as best solutions for the changing and challenging climate impacts in this study.

Accordingly, out of the total respondents 77.6% consider conservation agriculture to be the most important climate smart crop production practice, while 69.0% assume that, precise fertilizer application, followed by Response Farming and crop diversification with 58.4 and 57.6% respectively (Table 10). On the other hand Integrated pest management and Use of improved varieties were least evaluated by 46.5 and 42.0% of the respondent farmers respectively.

Table: 10 Importance of CSA Practices among Respondents in Shashemane woreda, 2019

CSA Crop Production Practices	Number of Respondents	Percent
Precise fertilizer application,	249	69.0
Integrated pest management,	168	46.5
Use of improved varieties,	151	42.0

Response farming	211	58.4
Organic and bio fertilizer application	178	49.0
Conservation Agriculture	280	77.6
Crop diversification	206	57.6

Source (Own survey, 2020)

It was also indicated during FGD and KI interviews that, socio-economical factors, and resource constraints, such as; lack of formal education, increasing cost of living, lack of adequate credit access and weaker Training and Extension services are the major hindering factors lowering the application of CSA crop production practices with different magnitudes in the study area.

4.2.4. Determinants of applying CSA crop production practices

The marginal effects from the MNL model that measured the expected change in the probability of a particular choice being made with respect to a unit change in an independent variable were also estimated (Table: 11).

Age of houshold head

The results showed that age of the household head was negatively associated with precise fertilizer application and Response farming at 5% significant levels, which indicates that, an increase in age of the household head by one year, the likelihood of using precise fertilizer application will be reduced by 0. 9%, and applying Response farming by 0.73% (Table: 11). This shows that as age increases, farmers shift from using precise fertilizer application and response farming practices to business as usual since both practices are labor-intensive ventures requiring healthy, risk-bearing and energetic farmers. Again, elderly farmers may not be aware of recent innovations or prefer to stick to the usual practices, even if they are aware. Similarly, Ali and Erenstein, (2017) noted that, old ages have negative relationship with adopting climate change adaptation and mitigation strategies. On the other hand, farmers may be more experienced with regard to climate variability and may have more accumulated knowledge about the climate of their environment leading them to better response farming strategies.

Houshold family size

Households with larger family size are supposed to be better in precise fertilizer application, integrated pest management, Use of improved varieties, Response farming, Organic and Bio fertilizer application and Conservation Agriculture practices, since they are less likely to have shortage of labor which is required to do different activities and practices, but not favored for Crop diversification. Accordingly, the coefficients of family size were positively significant at 0.05% probability level on these variables mentioned except on Crop diversification (Table 11). Accordingly, a unit increase in family size increased the probability of household participation in the above mentioned climate smart crop production practices with coefficient ranging from 4.1 to 6.5% when other variables are held constant. Hence, households with more family size were better placed to participate in CSA these practices than those with less family size. This might be so because of the practices are labor intensive since it requires application of different advanced techniques. While, the negative relationship between household family size and crop diversification could be related to the necessary resource to manage the family. This means that, household with larger family size requires more resource to satisfy the basic needs of the family which in turn negatively influences the purchasing power of the family to allocate finance for different crop species and varieties to exercise crop diversification. This is in line with Asrat and Simane (2018) stating increase in family size would increase expenditure for home consumption and creates financial constraints for other inputs such as improved crop varieties.

Table: 11 Model output of Determinant factors on CSA Crop Production Practices

Climate Smart Agriculture Crop Production Practices		Gender	Age house hold	Family size	Edu.	Farm size	Live stock asset	Local org. m/ship	Access to credit	Farmer income status	Access to media and weather	Training and Ext service	Farmers view on rainfall variab.	Farmers view on temp variab.	cons
Precise Fertilizer Application	Coeff.	-0.057	-0.009	0.049	0.018	0.060	0.088	-0.121	0.039	-0.040	0.004	0.192	-0.139	-0.095	0.866
	p value	0.342	0.002	0.001	0.611	0.077	0.083	0.305	0.516	0.439	0.951	0.008	0.083	0.135	0.000
Integrated Pest Management	Coeff.	0.004	-0.004	0.049	0.097	0.127	0.106	-0.003	0.038	-0.040	0.001	0.186	0.024	-0.125	-0.122
	p value	0.952	0.186	0.002	0.009	0.000	0.047	0.980	0.553	0.464	0.982	0.016	0.773	0.063	0.576
Use Of Improved Varieties	Coeff.	0.045	-0.004	0.057	0.090	0.032	-0.049	-0.102	0.128	-0.047	-0.099	0.104	-0.044	-0.110	0.133
	p value	0.479	0.121	0.000	0.014	0.361	0.351	0.404	0.044	0.382	0.112	0.169	0.598	0.096	0.537
Response Farming	Coeff.	-0.048	-0.007	0.065	-0.043	0.022	0.096	-0.034	0.215	-0.021	-0.009	0.116	0.464	0.178	-0.186
	p value	0.431	0.009	0.000	0.224	0.531	0.060	0.776	0.001	0.690	0.887	0.115	0.000	0.005	0.373
Organic and Bio fertilizer Application	Coeff.	0.024	-0.006	0.044	0.042	0.084	0.185	-0.069	0.037	-0.046	0.070	0.203	-0.088	-0.081	0.117
	p value	0.715	0.056	0.007	0.264	0.022	0.001	0.582	0.572	0.410	0.277	0.010	0.304	0.236	0.599
Conservation Agriculture	Coeff.	0.024	0.001	0.005	0.030	0.041	0.005	-0.065	-0.009	-0.021	-0.038	-0.086	0.639	0.541	-0.242
	p value	0.180	0.687	0.562	0.165	0.047	0.861	0.366	0.818	0.496	0.293	0.053	0.000	0.000	0.056
Crop Diversification	Coeff.	0.003	0.003	-0.022	0.086	0.025	-0.038	-0.007	-0.090	-0.021	0.093	0.126	-0.012	0.029	0.652
	p value	0.002	0.263	0.133	0.010	0.438	0.422	0.949	0.119	0.664	0.102	0.069	0.874	0.635	0.001

Note: the header "Determinant factors" spans the factor columns.

Source (Own survey, 2020)

Education level

Level of education of the household head positively influenced the adoption of climate smart crop production practices such as; integrated pest management, Use of improved varieties and crop diversification with coefficient values of 9.7%, 9.0 % and 10.4% respectively (Table 11). These coefficients indicate that, one more year of education increased the probability of using these practices by their respective percentages at 5% significance level. This could explain that, better educated farmers can be easily aware to the importance of these practices and can take risky measures to safeguard their agricultural activities against the prevailing challenges of climate change. Similarly, Gido, (2015) argues that, higher levels of education tend to build the innovativeness and ability to assess risks by farmers for proper farm adjustments.

Household farm size

Household farm size also showed positive influence on the use of climate smart crop production practices including; integrated pest management by 12.7%, Organic and Bio fertilizer application by 8.4% and Crop diversification by 21.5%. This implies that an increase in size of landholding by one ha, the probability of applying these practices increased by their respective percentages. This result revealed that, the availability of land provides opportunity for farmers to conduct these important technologies. This result is consistent with the result of Belay, (2017) who stated that, bigger farm size accrues benefits of economies of scale to farmers and also provide a means of diversifying production.

Livestock asset

There was a positive and significant relationship between Livestock asset and practices of CSA crop production like; integrated pest management and Organic and Bio fertilizer application. Resource-endowed farmers or those with greater value of productive livestock assets were likely to have an increased capacity by 10.6% to use integrated pest management and by 18.5%, to exercise Organic and Bio fertilizer application practices (Table 11). These assets enhance their ability to absorb the risks associated with failure or the time it takes before realizing meaningful effects of using CSA crop production practices. This is also consistent with the reports of Teklewold, (2016) who noted that, lack of productive assets usually limits the ability to adopt climate-smart practices that require huge resource allocation. Ochieng *et al.*, (2016) as well revealed that, wealthier households have higher capacity to invest in such measures and improve crop production.

Access to credit:

Access to credit had also a positive and significant influence on the use of improved crop varieties and implement response farming practice. The results indicated that farmers who received credit in previous farming season were 12.8% and 21.5% more likely to Use of improved varieties as well apply Response farming practices respectively (Table 11). Credit access enables farmers to meet costs involved in implementing CSA technologies, especially including expensive ones like use of improved crop varieties and necessary fertilizer. Similarly, Shiferaw, 2015) explained that, credit constraints negatively influence investment in improved seed and inorganic fertilizers, suggesting that credit-constrained households are less likely to adopt CSA technologies that require cash outlays.

Access to extension service

Access to extension service providers positively influences utilization of precise fertilizer application, integrated pest management and Organic and Bio fertilizer application practices.

Accordingly, as their contact with extension agents increased, the probability of applying precise fertilizer application, integrated pest management and Organic and Bio fertilizer application practices improves by 19.2%, 18.6% and 20.3% respectively. This result suggests that, extension service plays a crucial role in the implementation of new technology by the farmers. It further implies that the information disseminated by the extension service providers has an inclusion of a climate change dimension that could promote the use of practices to mitigate climate change impacts. This is consistent with the findings of a study in Zambia by FAO (2010) which indicated that extension agents were involved in a lot of activities that includes the delivery of climate information, agricultural inputs and administering credits in order to enhance crop production.

Previous experiences:

Past experiences of farmers related to rainfall and temperature variability had also positive influence on the application of some CSA crop production practices in the study. In this regard, Response farming, Conservation Agriculture and Crop diversification CSA practices better practiced by farmers who experienced in observing rainfall variability in the past 20 to 30 years had more probability of applying these practices by 46.4% and 64;0% respectively, whereas farmers who experienced temperature variability in the past years were more likely to apply Response farming, Conservation Agriculture and Crop diversification by 17.8%, 54.0% and 17.5% respectively (Table 11). However, previous study conducted by Gebeyehu (2016) had the contrary result, where frequent hailstorms were the greatest source of production risks related to climate change that discouraged adoption of production techniques posing threat to yield stability in a rural Amhara region of Ethiopia.

5. SUMMARY AND CONCLUSION

5.1. Summary

The study was conducted to assess long term climate trends and identify determinant factors of adoption to climate smart crop production practices in Shashemane woreda. For this purpose, long term meteorological data were accessed from NMA and farmers' perceptions on climate variability were gathered through; interviews, FGDs and KI participations in the study area.

Long term climate data analysis results in the study area showed that, the amount of annual rainfall has a declining trend with an average rate of -1.55 mm per annum, with an inter-annual variability of 19.35% cv value. These results indicated that, the inter-annual rainfall in Shashemane woreda is found to be relatively stable in amount and less variable in occurrence. Whereas, both mean annual maximum and minimum temperatures showed less inter-annual variability, but consistent and significant annual average increases by 0.031 and 0.018^{0}C respectively.

This study also found that, 90% of the respondent farmers in the study area were well aware of the changes in the climate, as manifested by 80% of them perceiving the existence of variation in temperature, while 87% variation in precipitation. These responses are in line with the results of long term climate data analysis.

However, only 21.6% of the respondents were ready to implement CSA Crop Production practices as basic solution to effects of the changing climate mainly due to some determinant demographic, physical, socio-economic and institutional factors including; age of household, family size, training and extension service, education, farm size, livestock asset, access to credit, farmers view on rainfall variability and farmers view on temperature variability.

The main CSA crop production practices influenced by the determinant factors in the area include; precise fertilizer application, Integrated pest management, Use of improved varieties, Response farming, Organic and bio fertilizer application, Conservation agriculture and crop diversification. Regarding the prioritization these practices, about 77.6% of the respondents consider conservation agriculture as the most important CSA crop production practice, while 69.0% assume that, precise fertilizer application more important followed by Response Farming and crop diversification with 58.4 and 57.6% respectively. However, Integrated pest management and Use of improved varieties were least evaluated by 46.5 and 42.0% of the respondent farmers respectively.

The results also showed that, age of the household head was negatively associated with precise fertilizer application and Response farming, while level of education of the household head positively influenced the adoption of climate smart crop production practices such as; integrated pest management, Use of improved varieties and crop diversification with coefficient values of 9.7%, 9.0 % and 10.4% respectively. Similarly, household farm size showed positive influence on; integrated pest management by 12.7%, Organic and Bio fertilizer application by 8.4% and Crop diversification by 21.5%.

There was also a positive and significant relationship between Livestock asset and practices of CSA crop production like; integrated pest management and Organic and Bio fertilizer application, in which those farmers with greater value of productive livestock assets were likely to have an increased capacity by 10.6% to use integrated pest management and by 18.5%, to exercise Organic and Bio fertilizer application practices.

Access to credit had a positive and significant influence on the use of improved crop varieties and implement response farming practice. The results indicated that farmers who received credit in previous farming season were 12.8% and 21.5% more likely to Use of improved varieties as well apply Response farming practices respectively.

Access to extension service positively influenced utilization of precise fertilizer application, integrated pest management and Organic and Bio fertilizer application practices by 19.2%, 18.6% and 20.3% respectively. Past experiences of farmers related to rainfall and temperature variability had also positive influence on the application of some CSA crop production practices, in which farmers who experienced better observation on rainfall variability in the past 30 years had higher application probability of Conservation Agriculture and Crop diversification practices by 46.4% and 64;0% respectively, while farmers who experienced temperature variability were likely to apply Response farming, Conservation Agriculture and Crop diversification by 17.8%, 54.0% and 17.5% respectively.

The FGD and KI interview participants further confirmed that, socio-economic factors, and resource constraints, such as; lack of formal education, increasing cost of living, lack of adequate credit access and weaker Training and Extension services are the major hindering factors lowering the application of CSA crop production practices with different magnitudes in the study area.

5.2. Conclusions

- Based on the findings of this study, the rainfall of Shashemane wereda is relatively stable and less variable that couldn't pose serious challenge on crop production, while the temperature is steadily increasing with less inter-annual variability.
- Although the farmers in study area are well aware of the changes in rainfall and temperature, most of them are not exercising CSA Crop Production practices, mainly due to limitations associated with; weather information and extension services, level of farmers education, credit access, which should be addressed by the respective institutions.
- It would be also vital to facilitate accessibility of credit through encouraging financing institutions to help farmer's investment in different climate smart crop production practices.
- Providing training and extension services is also important to improve their views on CSA and that would help them to diversify their crop production practices and remain resilient to climate change induced shocks.
- Government and local level development actors should encourage adult education, as majority of respondents were limited to know to climate smart crop production practices because of illiteracy.
- Finally, it is important to improve extension agents and woreda level agricultural offices experts' capability in climate smart agricultural crop production practices and main streaming it in their office.

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Appendix

SPI Value of the Study Area

Year	SPI9
1981	-1.408847737
1982	0.121604938
1983	-0.684773663
1984	-1.687654321
1985	0.323045267
1986	1.248765432
1987	-0.062139918
1988	0.296296296
1989	-0.691563786
1990	-0.588888889
1991	-0.374279835
1992	0.516049383
1993	-0.448765432
1994	-1.096707819
1995	-0.854526749
1996	0.374279835
1997	0.617078189
1998	0.485802469
1999	-0.63744856
2000	-0.663580247
2001	-0.803909465
2002	0.713168724
2003	1.288683128
2004	0.670987654
2005	-0.256995885
2006	0.230246914
2007	-0.541358025
2008	-1.911728395
2009	0.348353909
2010	0.013374486
2011	0.485185185
2012	0.424897119
2013	-0.756790123
2014	0.210288066
2015	1.680658436
2016	3.414403292

1. Household Questionnaire

My Name is Yeshiget Mengistu. I am a student at Hawassa University doing my MSc. Degree in Climate Smart Agriculture and Landscape Assessment. I am conducting my master's thesis on determinants of climate smart crop production practices by small holder farmers in shashemane district, central rift valley of Ethiopia by getting here in your kebele.

Dear respondents, the result of this study will help different stakeholders and policy makers to make appropriate measures on irrigation development in the future. Your responses are confidential. Therefore, you are kindly requested to provide genuine responses.

Thank you for your time and cooperation!

Instruction

- Where choices are available in the below question try to encircle.
- Where choices are unavailable try to give the answer on the space provided.

Questionnaire Identification

- Woreda................................ Kebele ………..………Location………………..…
- Agro ecology: Dega ☐ Weyinadega ☐ Kolla ☐
- Name of enumerator…………………………… Mobile No…………………
- Date …………………Starting time …………… Ending time…………

A. Farmers' Background Information

Marital status *(Please tick where appropriate)*

Single ☐ Divorced (separated) ☐

Married ☐ Widowed ☐

Gender Male ☐ Female ☐

Family size….. Education status……………

If any other specify………………

1. What is the occupation of the household head?
   i. Crop farming ☐
   ii. Livestock Farming ☐
   iii. Mixed farming, ☐
   iv. If mixed the dominant one is……………………
   v. Others (specify)………………..

2. How many years have you been in the current farming system? ………………….

B. Farmer's Perception on Climate variability and other natural resources

1. What is your observation/perception on climate variability, soil fertility status, tree cover and crop production around your environment in this year than? (Using the following Key: 1 very low, 2 low, 3 no change, 4 high and 5 Very high. Put (√) in the box provided).

Indicators	30 years ago					10 years ago					2 years ago				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Temperature															
Rain															
Cropproduction/yield															
Crop failure															
Drought															
Floods															
Soil fertility															

Others (specify)………………..

2. What is your perception on expected effect of the following climate smart agricultural practices on your farm? (Use the following Key*):*

1= strongly disagree; 2= Disagree; 3=Neutral / Undecided; 4= Agree; 5= strongly agreeand put (√) in the box provided

Indicators	Statement	Perception rate				
		1	2	3	4	5
Natural resource conservation	i. Natural resources must be protected for the next generations					
	ii. I have to protect natural resources even if it will lead to incurring losses in the short run					
Soil management practices	i. Minimum tillage reduces soil erosion, disturbance and exposure					
	ii. Crop rotation reduces soil degradation					
	iii. Leguminous species and diversification of crops can protect soil from erosion					
	iv. Mulching or Retaining crop residues reduce weed growth, reduce moisture loss and reduce erosion by water and wind					
	v. Soil fertility can be improved by application of green manure					
	vi. Soil fertility can be improved by application of compost					
Agro forestry	i. Growing trees in association with crop production generate additional income and able to improve my livelihood?					
	ii. intercropping can improve soil fertility					
	iii. boundary planting and windbreaks can protect soil erosion and improve water retention of the soil					
	iv. growing multipurpose trees and shrubs in steeper slope land can reduce soil erosion and improve soil fertility					
	v. alley cropping provides nutrients specially nitrogen to the soil					
Water management Practices	i. terraces can improve the water retention capacity of the soil					
	ii. slope stabilization improve the water availability in the soil					
	iii. drought resistance crops (improved seeds) are selected in low rain fall season					
	iv. by storing water (irrigation) farming operation can be done during the dry season					
Crop management practices	Crop diversification to coop with failure Drought tolerant crop Varity can reduce drought failure IPM can reduce insect and pest failure Response farming can be reduce climate impact					

1. **Physical Factors *(Please tick where appropriate)***

Farm Land Nature and Size

Total number of parcels ……………. Size …………. *Timad* (to mean '*Oolchaasangaa'* in *Afan oromo*)

Type of parcel	Size in *timad*	Distance from the house (in minutes)	Land Quality (fertile, Moderately Fertile, degraded , severely degraded,)	Slope (plain , medium, sloppy)	Types of soil or/and water conservation practices applied	The land ownership type (ownership by title, rent or other)
Parcel 1						
Parcel 2						
Parcel 3						
Parcel 4						

a. Average house distance from the proxy market (in Min.) …………….Minute

b. Average house distance from the main road (in Min.) …………….Minute

2. **Economic Factors**

A. Do you posses an irrigated agriculture?

1=Yes ☐ 0=No ☐

B. If yes (for a question), what is the size of the irrigated land in timed?……………

C. Currently how many of the following livestock do you have? (NB: Quantities registered will be converted to Tropical Livestock unit)

cows	Oxen	Bull	Calf	Heifer	Goat	Sheep	Horse	Mule	donkey	Poultry

D. Crop production and inputs used by household

NO	Crop type	Land size in Timad	2010 production in quintal	Type of seed used (local, improved)	Fertilizers in Kg per hectare
1.	Teff				
2.	Barley				
3.	Wheat				
4.	Maize				
5.	Chickpea				
6.	Lentil				
7.	Pea				
8.	Faba bean				
9.	Potato				
10.	Other				

E. Do you worry about food security?

1=Yes0=No ☐ ☐

F. Off-Farm Income

Apart from farm income, do you receive income from other sources?
1=Yes 0=No ☐ ☐

If yes, please indicate the other sources of income

Type of earning (income)	Average annual income (in birr)
Salary	
Transfer earnings from relatives (including remittance)	
Value of gifts received	
Income from Land rented out	
Daily Laborers	
Other incomes (specify) ………………..	

5 Institutional Factors

A. Extension Services

1. Has any household member receive extension service in the last 12months?

1=Yes ☐ 0 =No ☐

2. If yes (for a), how many times do you usually meet with extension agents per cropping year? ………………………………………………………….

3. On what topics you get support from extension service?

………………………….. , ………………………….. , ………………………….. , ………………………….. , ………………………….. , ………………………….. ,

4. Have you got extension service in the above mentioned Climate smart agricultural practices?

1=Yes ☐ 0 =No ☐

5. Which institution provides you the extension service? Put(√) in the box provided.

Extension service provider	
1. Government (by extension workers-DA)	
2. NGOs/development agencies	
3. Other farmers	
4. Others (specify)……………………..	

B. Land Ownership

For whom do you think farm land belongs for natural conservation practices? Put (√) in the box provided.

Government	My own	I am not sure

Do you expect that you will use the land throughout your life time? Put (√) in the box provided.

I doubt	No, I may loss it	Yes, I am sure

Do you think land ownership titles motivate farmers to adapt water management, soil management and agro forestry practices and any other conservation activities?

1=Yes 0 = No

C. Training

Have you ever attended a training that improves your farmoperation?
1=Yes0 =No
If yes in (c), then complete the table below.

Training tiltles *(See codes below)*	Number of times	Training organizers *(See codes below)*

So, how did you feel about the importance of the training? Put(√) in the box provided.

Unimportant at all	A little bit good	I don't know	Very important

Information Access

1. Do you have radio/TV?

1=Yes 0 =No

2. Do you think radio/TV provides you information on climate change and its adaptation or mitigation practices? Put(√) in the box provided)

1=strongly disagree	*2= Disagree*	*3=Neutral/Undecided*	*4= Agree*	*5= strongly agree*

3. Do you have regular access to weather forecasting information?
1=Yes 0 =No
4. Do you usually participate in farmers' field days?
1=Yes 0 =No

Organization

1. Are you a member of youth or women or farmers cooperative association?
1=Yes 0 =No
2. Do you think being member of peasant association, capacitate farmers to improve their mulching, compost application and agro forestry practices adoption?

1=Yes 0 =No

Credit Access

1. Did you have an opportunity to access credit?

1=Yes ☐ 0 =No ☐

2. If yes in (1), fill the table below:

Credit source	Granted? 1=Yes 0=No	Credit type 1=Money 0=In kind	What was the purpose of credit? *(See codes below)*	If not granted, give reasons *(See codes below)*

D. Farm Operations

Do you practice the following farm activities?

NO	Activity	Yes	No
1	Use crop diversification / Farming varieties of crops/		
2	Alterations in cropping patterns and rotations		
3	Use drought resistance crops		
4	Use soil and water conservation practices (Terracing)significantly		
5	Inclined to non farming activities		
6	Use storage water		
7	Applying agro forestry (Planting trees)		
8	Use of high irrigation water		
9	Use sufficient amount of fertilizer		
10	Use improved seeds sufficiently		
11	Use of BBM technology		

E. Climate Smart Agricultural crop production Practices

1. Hove you practiced the following common climate smart crop production practices?

a) conservation agriculture

b) integrated nutrient and soil management

c) mulch cropping

d) alterations in cropping patterns and rotations

e) crop diversification

f) using high quality seeds and planting materials of adapted varieties

g) integrated pest management

h) grasslands management

i) Water and irrigation management

j) landscape-level pollination management

k) organic agriculture; and

l) Agro forestry

2. If you may practice some of the above practice why you encouraged performing them?
……
……
…………………………………………………

3. If you did not perform them what factors limits you to do the practices?

a. Lack of capital

b. Lack of mulch or crop residues

c. Lack of labor

d. Lack of animal feed(fodder)

e. Lack of land

f. Lack of access to seedlings

g. Poor soils

h. Lack of product market

i. Lack of infrastructure

j. Lack of information

k. Others (specify)……………………

3. Points for FG Discussion

1. Is there climate change in the area? How do you feel about?
2. What is the solution do you think so?
3. What are the factors affecting the application of Climate smart crop production practice in this area?
4. What are the challenges to implement the practices in this area?
5. What is the climate smart agricultural crop production practices implemented in this area?

4. Checklist for Field Observation

1. Environment
2. Relief (plain, plateau, mountain, steep slopes)
3. Land-use and land cover
4. Soil aspects
5. Water bodies
6. socio- culture
7. Population settlement patterns
8. Religion
9. Culture, value, traditions
10. Social relations neighborhoods, network, reciprocity
11. Economy/Sources of livelihood/ and Infrastructure
12. Main source of livelihood: mixed farming, non-farm activities
13. Crop types: dominant in terms of area cultivated and size of harvest during meher and belg seasons, source of staple food
14. Livestock: type, size, raising practices
15. Situations of social and economic infrastructure: transport (road),marketing, extension

AUTHER BIOGRAPHY

The author was born in Adami Tulu District, East Showa Zone, Oromia Regional State, Ethiopia on November, 1987 She attended her elementary education at Batu Elementary school from 1991-199 She began her high school at Batu Senior Secondary School in 2000 and completed in 2002 Upon her completion, she joined Holeta TVET with Animal Sc, and then Hawassa University, Wondo Genet Collage of Forestry and Natural Resource and graduated with Bachelor of Science degree in Natural Resource Management in 20012 She was employed as Natural resource expert in 2012 At Shashemene woreda Agriculture and Natural resource office. Following her seven-year service, she joined the Post graduate Program, in Wondo Genet Collage of Forestry and Natural Resource at Hawassa University to pursue her MSc study in Climate smart Agricultural landscape assessment.