CONTRIBUTION OF CONSERVATION AGRICULTURE FOR CLIMATE CHANGE ADAPTATION AND DETERMINAT FACTOR , IN THE CASE OF KILITEAWLAELO DISTRICT, EASTERN TIGRAY, ETHIOPIA.

M.Sc. THESIS

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A THESIS SUBMITTED TO THE DEPARTMENT OF AGRO FORESTRY, WONDO GENET COLLEGE OF FORESTRY AND NATURAL RESOURCES, SCHOOL OF GRADUATE STUDIES, HAWASSA UNIVERSITY WONDO GENET, ETHIOPIA

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE MASTER OF SCIENCE IN CLIMATE SMART AGRICULTURE AND LAND SCAPE ASSESSMENT

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APPROVAL SHEET-I

This is to certify that the thesis entitled "Contribution of Conservation Agriculture for Climate Change Adaptation, and Determinant Factor in the Case of Kilite-awlaelo District, Eastern Tigray, Ethiopia**,**" submitted in partial fulfillment of the requirements for the degree of Master's with specialization Climate Smart Agriculture and Land scape Assessment, the Graduate Program of the Department of Agro forestry, and has been carried out by Nebyat Haileslasie Id. No CSALA R/015/10 under our supervision. Therefore we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

BEYENE TEKLU (Ph.D.) ____________________ __________________

Signature Date

KIDIST FIKADU (Ph.D.) __________________ ___________________

Signature Date

APPROVAL SHEET-II

We, the Undersigned, members of the board of examiners of the final open defense by Nebyat Haileslasie Gebrewubet have read and evaluated her thesis entitled in "Contribution of Conservation Agriculture for Climate Change Adaptation, and determinant Factor in the Case of Kilite-awlaelo District, Eastern Tigray, 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 and Land Scape Assessment.

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Nebyat Haileslasie Gebrewubet

CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the thesis entitled "Contribution of Conservation Agriculture For Climate Change Adaptation, and determinant Factor in the Case of Kilite-awlaelo District, Eastern Tigray, Ethiopia" in partial fulfilment of the requirements for the award of the degree of Master of Science and submitted to the School of Graduate Studies, Wondo Genet College of Forestry and Natural Resource, Hawassa University is an authentic record of my own work carried out during the period from October, 2018 to July 2019 under the supervision of Beyene Teklu (Ph.D.)

The work contained in this thesis has not been previously submitted for similar or for other purpose at any higher institution or elsewhere to the best of my knowledge.

Nebyat Haileslasie Gebrewubet	___________	____________
Student Name	Signature	Date

LIST OF ABBREVIATIONS AND ACRONYMS

ACT	African Conservation Tillage
CA	Conservation Agriculture
CARE	Cooperative for America Relief Everywhere
CIMMYT	International Maize and Wheat Improvement Centre
CRGE	Climate-Resilient Green Economy
CSA	Climate Smart Agriculture
CV	Coefficient of Variance
DA	Development Agent
FAO	Food and Agriculture Organization of the United Nations
FAPDA	Food and Agriculture Policy Decision Analysis
FGD	Focused Group Discussion
GDP	Gross Domestic Product
GHG	Greenhouse Gas
HHs	House Holds
KI	Key Informant
MoA	Ministry of Agriculture
PPS	Proportional to population size
SPSS	Statistical Package for Social Science
WoARD	Woreda office of Agriculture and rural Development

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ABSTRACT

Increasing population pressure and resulting fragmentation of farmlands induced continuous cultivation has been the major contributor for climate change. Developing world attempts various programs and initiatives which enhance HHs to choose different CA techniques that enable to adapt climate change. Therefore, understanding the factors affecting to choose CA plays a key role. This study was designed to assess the contribution of conservation agriculture for climate change adoption with specific reference to Kilite-awlaelo district. The main objective of the study was to investigate the contribution of conservation agriculture towards climate change adaptation. A survey was conducted with a structured questionnaire with 150 households that were randomly selected from three peasant association of which 74 were CA adopters and 76 non-adopters. Semi-structured interviews were conducted with smallholder farmers and focus group discussion with key informants, agricultural experts and peasant association administration leaders. Data from questionnaires, interview and the focus group discussion were analyzed by using descriptive statistics /t-test and chi-square/ and binary logistic regression. The result indicated that most of CA adopters were in active age group 35 to 65 and more educated than non-adopters. Intercropping/crop rotation, leaving crop residue, and adding organic matter were the CA technologies widely implemented in the study area. Level of education, access to extension and credit had significant positive effect on CA adoption while engagement on off-farm activities had significant negative effect. Level of education and access to extension services increased the livelihoods of CA adoption by 10.9 and 2.8 times more than those who did not attend school and do not have access to extension services. Finally, the study recommends that as the conservation agriculture forced farmers to boost the tolerance tendency against climatic change. Then the local government and all responsible bodies could be given more attention over it.

Keywords: Extension service, Farm land, Household, Highland, Off-farm

1. INTRODUCTION

1.1. Background

Agriculture in Ethiopia has a long history as it was believed to be started about 11, 000 years ago (FAO, 2013). The existence of diverse agroecology and the availability of varies natural resources are claimed for sustainable agricultural production for thousands of years (Lemlem Habtemariam *et al*., 2016). However, today this age-old agricultural sector is threatened by climate-related hazards. Climate hazards such as drought, floods, and erratic rainfall are signs of climate change caused by increases in greenhouse gases in the Earth's atmosphere mainly due to anthropogenic activities (Cook, 2013:Cook *et al*., 2016). Despite a huge claim on industry and transportation sectors as major contributors of greenhouse gasses emission, agricultural sector is also contributing about 10% - 17% Smith *et al*. (2007); Todd *et al*. (2011) through direct agricultural activities and 32% indirectly via land-use change of global anthropogenic greenhouse gases emission (Greenpeace, 2008). The effect of agricultural activities on climate change could be considered as suicides as climate change affect agricultural yield by influencing climate variables (Foley, 2011).

This calls for the integration of greenhouse gasses mitigation mechanisms with agricultural activities for reconciliation of the trade-off with climate change to meet the food and feed demands of the rising world population (Foley, 2011). The attempts of enhancing productivity through inorganic fertilizer application and pesticide use are the major contributors to greenhouse emission as its application has increased by 500% and 850% respectively over the last half-decade (McKenzie and Williams, 2015). However, recently there is a consensus on reducing environmental impacts imposed by the use of synthetic inputs through a sustainable agricultural intensification approach, which is also known as climate-smart agriculture (FAO, 2013). Climate-smart agriculture has been promoted as a solution to overcome the challenge of how to enhance production and productivity without burdening the environment. Climate-smart agriculture approaches are assumed to have a "triple win" effect as it is designed to enhance productivity by growing adaptable crops with minimal CO_2-emissions (FAO, 2013). Climate-smart agriculture has recently received huge attention and gained a strong position within the global development discourse. Its approach of transforming agricultural practices and systems holds a promise of ensuring food security in the face of the dual challenges of climate change and resource scarcity (Lipper *et al*., 2014). As a consequence, agriculture and its linkages to climate change and adaptation is now the focus of attention by a wide part of the international community, with actors such as the World Bank and the United Nation Food and Agriculture Organization leading the way.

In Ethiopia where about 85% of its population is heavily dependent on agriculture, smallholder farmers are vital for ensuring sustainable food and biomass supply while maintaining ecological integrity (FAO, 2010). However, this production system is highly affected in recent years due to population growth coupled with the farmland fragmentation. Hence, climate-smart agricultures are crucial to achieve future food security without burdening the environment. It integrates the three dimensions of sustainable development (economic, social and environmental) by jointly addressing food security and climate challenges (FAO, 2010). Implementation of CSA would address the bottlenecks of agriculture through sustainably increasing agricultural productivity and incomes by building resilience to climate change and reducing greenhouse gas (GHG) emissions. Of different approaches of CSA, conservation agriculture (CA) is commonly implemented in developing countries where there is intensive cultivation and land degradation is high (FAO, 2010). Indeed, CA was born in the United States (U.S.) after catastrophic droughts cause harvest loss (Haggblade ,S. and Tembo, 2003). In Ethiopia, CA practices such as reduced tillage and terracing have long been widely practiced particularly in the northern highlands of Ethiopia, despite its official promotion in earnest since 1998 through demonstration of the technologies on farmers field (Melaku Jirata, 2016).

Conservation Agriculture is acknowledged (recognized) for enhancing productivity with minimal nutrient mining and its positive ecological sustainability. Different studies reported 20 to 120% yield advantages of CA compared to conventional agriculture (Melaku Jirata, 2016). The possibility of reducing soil nutrient loss through erosion and minimizing nutrient mining through leaving residues on the field are among many acknowledged for yield advantage. Thus, the study presented the contribution of conservation agriculture for climate change adaptation, in the case of Kilite-awlaelo district, Eastern Tigray, Ethiopia.

1.2. **Statement of the problem**

Conservation Agriculture as a method and its various principles has been practiced long before people started to talk about climate-smart agriculture (FAO, 2001). This is witnessed by its birth in the 1930s in the US following the catastrophic droughts (Arslan *et al.*, 2014). Agriculture is the backbone for the Ethiopian economy. Hence, the Government initiated Climate-Resilient Green Economy intending to protect the country from the adverse effects of climate change and to build a green economy that will help realize its ambition of reaching middle-income status before 2025. However, it has been exposed in to challenges of catastrophic droughts several times by the case of climate uncertainties and increasing frequency of droughts enforced the farmers to switch to new and sustainable farming practices such as CA. Thus CA was taken as one approach for achieving the desired objectives of building a green economy through enhancing agricultural productivity with minimum soil nutrient loss. Studies indicated that, the advantages of CA in terms of resource use efficiency, environmental conservation, and profitability, unlike other types of agricultural production activities that are labor-intensive and demand more inputs (Rockstrom *et al*., 2009). Indeed, the success of CA is not uniformly acknowledged all over the world as its adoption varies from place to place. The level of adopting a given technology is partly determined by the available resources such as land, institutional-setups, knowledge, and experiences of farmers (Rockstrom *et al*., 2009).

Although, different conservation activities have been implemented in the highlands of the Tigray region, particularly in the study area; there is limited information about how these conservation activities contributed to yield advantage and climate change adaptation. Furthermore, there are little empirical studies on factors that influence CA adoption. Therefore, this study focused to reveal the role of conservation agriculture towards climate change adaptation from a farmer's point of view in Kilite-awlaelo Woreda, Tigray Region.

1.3. Objective of the study area

1.3.1 General Objective

To investigate the contribution of conservation agriculture for climate change adaptation and factors influencing conservation agriculture adoption from a farmer's point of view at Kilite-awlaelo district, Eastern Tigray, Ethiopia.

1.3.2. Specific objectives of the study

- ❖ To assess the types of conservation agriculture practiced in the study area
- ❖ To assess the roles and contribution of conservation agriculture towards climate change adaptation in Kilite-awlaelo area
- ❖ To ascertain the factors that influence adoption decision of farmers to practice conservation agriculture in the study area.
- ❖ To assess the perception of farmers on climate change trend and variability of in the study area

1.4. **Research Questions**

- Do farmers in the study area practice various types of conservation agriculture?
- Is practicing conservation agriculture serves as a means for climate change adaptation in the study area?
- What was the role and contribution of conservation agriculture practice being implemented at Kilite-awlaelo district?
- What are the key factors that influence farmers' decisions of adopting or not adopting the various CA practices being implemented in the study area?
- What is the perception of farmers to ward climate variability on their local area?

1.5. **Significance of the Study**

Conservation agriculture is currently being practiced to varying degrees in different countries of the world. Economic profitability of CA in the smallholder farmer context is a crucial factor. Farmers who are new or are at the initial stages of converting to CA require tangible evidence on the benefits and impacts of CA. Different studies have also revealed that the majority of the Ethiopian population in almost all regions of the country is severely affected by chronic and transitory food insecurity. A shift to CA involves many changes in best-practice crop agronomy and considerable adaptation of the technology to different crops and soils. A systematic program of applied and adaptive research is needed to develop best-practice for the emerging CA in Ethiopia. By pointing out the adoption decision and contribution of CA, this study has provided guidance and supplement information to policy makers, extension officers, and individual farmers that may wish to conduct similar studies for enhancing the program's effectiveness.

1.6. Scope and limitation of the study

The study was focused on three kebelles, due to the limitation of resources in terms of time, budget and transport facility. In addition to this, it did not include the soil organic content between the adaptors and non-adaptors of farm land. Lack of detail information, on the appropriate types of seedlings planted as an agroforestry practice was also limitation of the study. But it takes in to account only the condition of presence of CA and its role to mitigate the effect of climate change on the livelihood of farming community.

2. LITERATURE REVIEW

2.1. Concepts and principles of conservation agriculture

Conservation agriculture can be defined as any soil management that leaves the soil surface less exposed to erosion to conserve soil moisture, through minimal soil disturbance, permanent soil cover and crop rotations (FAO, 2001). The improving soil fertility and organic matter content of the soil enhance water infiltration and facilitate crop production whereas crop rotation helps to reduce the use of pesticides and herbicides in the long run (Derpsch, 2005). Conservation agriculture is known in different ways such as conservation tillage, no-tillage, and zero-tillage; direct seeding/planting and crop residue mulching (Mlonzi, 2005). The positive impacts of CA for agricultural, environmental safety profitability and social stability have been frequently reported in addition to its role for labor- saving which is basic particularly when there are labor shortages (FAO, 2011).

According to CARE. (2008), CA encompasses a set of complementary agricultural practices based on three principles of minimal soil disturbance, permanent soil cover and diversified crop rotation are widely practiced in the developed world to improve soil health, reduce water use, and as an adaptation tool for climate change. However, there are many challenges to implementing CA in the developing world. Among the challenges are the perceptions that conventional tillage is necessary for high crop production. Insufficient affordable and locally produced equipment, limited knowledge and experience with CA practices, the perception that CA worsens weed, pest and disease infestation, and limitations concerning the policy environment and extension services.

2.2. **Types and Benefits Conservation agriculture**

2.2.1. **Minimal soil disturbance**

Minimum soil disturbance refers to low disturbance no-tillage and direct seeding, the disturbed area must be less than 15 cm wide or less than 25% of the cropped area (whichever is lower), therefore there should be no periodic tillage that disturbs a greater area than the aforementioned limits (FAO, 2001; Calderucio and Ma, 2008). Strip tillage is allowed if the disturbed area is less than the set limits land preparation for seeding under no-tillage involves rolling the weeds, previous crop residues or cover crops, or spraying herbicides for weed control, and seeding directly through the mulch (FAO, 2011).

2.2.2. Permanent soil cover

Permanent soil cover protects the soil from rain, sun, and wind. It reduces soil erosion and protects the fertile topsoil, so preventing the silting of rivers and lakes and stops the soil surface from sealing, reduces the amount of precious rainwater that runs off (FAO, 2001). It suppresses weeds by smothering their growth and reducing the number of weed seeds, this reduces the amount of work needed for weeding, it is also increases the soil fertility and the organic matter content of the soil, and on the top of that it increases soil moisture by allowing more water to sink into the ground by reducing evaporation (FAO, 2001). Decomposing vegetation and the roots of cover crops improve the soil structure and make the clumps and lumps in the soil more stable making it harder for the rain to break them up and wash them away. Earthworms and other forms of life can prosper in the cover as well as in the soil, it also stimulates the development of roots, which in turn improve the soil structure, allow more water to immerse into the soil, and reduce the amount that runs off (FAO, 2011;Derpsch, 2005). There are two main types of soil cover:

I. Living plant material: crops and cover crops.

II. Mulch or dead plant material: crop residues and pruning from trees and shrubs, to keep the soil covered the use of a combination of both mulch and living plants can be applied, also to obtain a good soil cover, leave crop residues such as maize and sorghum stalks in the field (FAO, 2001).

2.2.3. Diversified crop rotations

The rotation of crops is not only necessary to offer a diverse "diet" to the soil micro-organisms, but as rooted in different soil depths; they can exploring different soil layers for nutrients (FAO, 2001). Nutrients that have been leached to deeper layers and that are no-longer available for the commercial crop can be "recycled" by the crops in rotation. This way the rotation crops function as biological pumps. Furthermore, a diversity of crops in the rotation leads to a diverse soil flora and fauna, as the roots excrete different organic substances that attract different types of micro-organism, which in turn, play an important role in the conversion of these substances into plant nutrients (FAO, 2001; ACT, 2008).

2.2.4. Environmental and socio-economic impacts of conservation agriculture

Conservation agriculture has a significant impact in Environment, biodiversity and soils through reducing soil erosion, increased rainwater infiltration, and build-up of soil organic matter for increased soil moisture storage. Conservation agriculture can improve biodiversity on farm, community level, and support improved ecosystem services such as water and nutrient cycling. It can also support flood control through improved water infiltration in agricultural fields. The greenhouse gas emissions and carbon sequestration are one of the evidence of the conservation agriculture that can help to mitigate climate change by reducing existing emission sources and sequestering carbon in soils and plant biomass (Baker *et al.*, 2007). Estimate that the conversion of all croplands to conservation tillage globally could sequester 25 G.t C over the next 50 years (Baker *et al.*2007). This is equivalent to 1833 Mt CO_2-eq/yr., making conservation tillage among the most significant opportunities from all sectors for stabilizing global greenhouse gas concentrations.

Scaling down these global estimates to the continental, landscape or plot scale to estimate the mitigation potential of conservation agriculture in sub-Saharan Africa entails significant challenges. Overall there is scarce of data on the GHG impacts of CA practices, especially for developing countries in the tropics and subtropics (Milder *et al*., 2011).

Soil fertility: In terms of soil fertility, the improved soil structure resulting from conservation agriculture enhances aeration and other conditions required for efficient nutrient cycling. Soil organic matter has been found to increase significantly over time in conservation agriculture systems, primarily due to the introduction of additional organic matter as crop residues or mulch and to the reduction or elimination of tillage, which tends to accelerate the oxidation of soil organic matter (Hobbs *et al*. 2007; Derpsch *et al*., 2010). Zero tillage systems are also associated with increased levels of available phosphorus in the upper soil layer (e.g. 0-5 cm), due largely to the role of biological processes in phosphorus cycling (Milder *et al*., 2011).

Food security: Sustained and stable food production generated by conservation agriculture systems can significantly improve the food security and nutritional status of vulnerable households and communities. Conservation agriculture can help stabilize yields in the face of climate shocks such as droughts by reducing evapotranspiration and regulating soil temperatures as well as supporting the management of pests and diseases in crop production if appropriate crop rotations and combinations are used. These benefits are especially important for poor and vulnerable smallholder farming households. Agricultural principles, practices and technologies in Ethiopia, soil tillage has been associated with increased soil fertility in the past. It has recently been recognized that, in the long term, this process leads to a reduction of soil organic matter. Soil organic matter not only provides nutrients for the crop, but is also a crucial element for the stabilization of soil structure. Therefore, most soils degrade under prolonged intensive arable agriculture. This structural degradation of the soils results in the formation of crusts and compaction, ultimately leading to soil erosion and reduced agricultural productivity. As a result, the conservation agriculture components that are currently being promoted include:

Crop residue management: The success of conservation agriculture in Ethiopia is highly dependent on crop residue management. Crop residues provide protective cover for the soil and increase soil infiltration. Research has shown that when 35 percent of the soil surface is covered with uniformly distributed residues, splash erosion will be reduced by up to 85 percent. Approximately two tons of maize residues per hectare are necessary to obtain 35 percent soil cover, which has been established as the minimum amount required for achieving a substantial reduction in relative soil erosion (Tolesa D, 2001). In many parts of the country, however, crop residues have traditionally been used for multiple purposes including fuel, building materials and animal feed, which conflict with their use in conservation agriculture. Among these, livestock-related use (feed) is probably the most widespread in the country.

2.3. Conservation agriculture in the context of Ethiopia

In terms of climate-smart agriculture and food security, Ethiopia is an interesting country for several reasons. The country has Africa's second largest population, estimated to be 99 million in 2015 (World Population Review, 2016). The annual population growth is declining, but is still one of the fastest growing countries in the world with 2.6% growth rate according to the Ethiopian Central Statistical Authority (2008), 3% growth rate according to World Population Review (2016). Following from this, Ethiopia will contribute significantly to Africa's population growth, and will likely hit well above 200 million in the next 30 years. Although, the country has experienced significant economic growth the last years with an annual GDP growth rate of impressive 10% (FAO *et al*., 2015). It is still a heavily agriculture dependent economy with about 80% of the workforce being involved in food production and agriculture constituting roughly 44% of GDP (FAPDA., 2014).

Food insecurity Considerable progress has been done on reducing food insecurity in Ethiopia the later years. The Ethiopian government has increased its focus in long term agricultural development and implemented. For instance a widespread social protection programmes (the Productive Safety Net Programme or PSNP) in 2005. A positive effect of these efforts is that the country recently reached the Global sustainable development on halving the proportion who suffers from hunger. Unfortunately, about 32% of the population are still undernourished, chronic malnutrition, and periodic localized severe food insecurity continue to affect tens of millions (FAO *et al*., 2015). Serious production shortfalls related to droughts can in bad years significantly reduce food production and consumption of millions of households. Even in normal years, the level of food insecurity is high, with 35% of children under five being underweight and 11% of children dying before the age of five (Chamberlin, J. and Schmidt, 2012).

2.3.1. Experiences with CA in Ethiopia

The experience with CA in Ethiopia is limited. However, some projects have been implemented and the following section draws heavily on a meta-study by FAO (2016), on CSA and CA practices , which provides some of the most comprehensive and updated information on the subject.

During the initial period of CA from 1999 to 2003, trials indicated that CA plots on maize, Teff, and sorghum had higher yields compared to conventional tillage. They also indicated lower production costs. Despite CA having been introduced in Ethiopia over 16 years ago, adoption of the practice remains low and has not progressed as fast as it could have. Since its introduction, CA has been promoted mainly by NGOs and the private sector with support from agricultural offices at all levels. The Ethiopian government has put in place policies, strategies, and manuals that are designed to support CA practices and other forms of sustainable agriculture methods aiming at restoring ecosystems and managing natural resources. The Agricultural Transformation Agency's target for 2014 was to have 50,000 farmers practicing CA and as a result of the promotional work that has been done, CA has been adopted by a number of smallholder farmers in many parts of the country. It has been indicated that adoption has been most successful in the areas where CA have been adequately demonstrated for example in some parts of Oromia, Amara, and Tigray. However, adoption rates in Ethiopia are not well enough documented. In terms of adopting different CA components Wondwossen T. *et al.* (2008), from two districts in Ethiopia found that those farmers who had adopted all three components of CA had higher yields than non-adopters, and that yields increased by the number of components adopted. Similarly, adoption of the three components substantially increased labor productivity (yield per unit of labor), implying that most labor is saved from full adoption of all the CA components. The promotion and adoption of CA technology in Ethiopia is constrained by various factors.

2.3.2. Challenges to conservation agriculture promotion in Ethiopia

Conservation agriculture promotion in Ethiopia has been implemented mainly by NGOs and private sector organizations, while emphasis given by responsible government institutions like the Ministry of Agriculture, in particular the Agricultural Extension Directorate, has not been sufficient in the past. Conservation agriculture is not adequately integrated into the existing agricultural extension delivery system of the MoA. In addition, since conservation agriculture has mostly been implemented by NGOs, there has not been adequate government follow-up, support and appropriate monitoring to ensure sustainability and wide adoption of the practice.

Open grazing system: Open grazing is a challenge not only to conservation agriculture in Ethiopia, but also to overall agricultural development and environmental sustainability. Open grazing results in the removal of crop residues from conservation agriculture fields and causes soil compaction that results in hard pans and difficulty in planting using simple planters or simple rippers that are suitable for smallholders. If livestock are accustomed to feeding on crop residues, a conflict of interest can be created when crop residues need to be kept for mulching. Crop-livestock conflicts need to be considered when promoting conservation agriculture.

Lack of alternative energy sources: In most parts of rural Ethiopia, crop residue is not only used as a livestock feed, but also as a fuel wood for cooking purposes. Most farmers do not have woodlots and hence crop residue is one of the main sources of fuel wood for cooking. In promoting conservation agriculture there is a need to consider mechanisms to support farmers to access alternative energy sources.

High input prices: Prices for high-quality inputs such as herbicides, fertilizer, improved seeds and implements have been steadily increasing in Ethiopia and at times the prices are beyond the capacity of many smallholder farmers. One example is non-selective herbicides which, according to farmers, have more than doubled in price within three years. A means of supporting smallholder farmers to access inputs so that they can undertake conservation agriculture and other CSA practices is needed.

Shortage of credit facilities: Credit service is an important factor that influences adoption of agricultural technologies, especially for poor farmers who often have limited financial resources for purchasing agricultural inputs and implements.

2.4. **Factors Influencing Adoption of CA**

Factors that Influence the adoption of CA included both farm and farmer characteristics. These factors in other literature have been identified as institutional, physical, personal and socio-economic factors. These include:

2.4.1. **Socio-economic Factors**

Farmer's age

Age is an important factor that influences the probability of adoption of new technologies because it is said to be a primary latent characteristic in adoption decisions (Akudugu *et al*., 2019). Farmer's age has the expected negative and significant influence on the chances of farmers participating in adopting innovation like Conservation farming (Amir, 2006). The negative sign for the age variable could be understood from the commonly observed negative correlation between the age and adoption decision for most technologies in dynamic economic environments, in other words, younger farmers tend to be more willing to adopt than their older counterparts (Amir, 2006).

On top of that, older farmers tend to be risk adverse and may avoid innovations in an attempt to avoid risk associated with the initiative, furthermore being older creates a conservative feeling among farmers and hence resistance to change. On the other hand older farmers with farm experience are more likely to practice all CA technologies; they are expected to use their farming experience to decide to adopt new technology (Mazvimavi, and Twomlow, 2009).

Education

Education is a major factor that can influence the adoption of any innovation. Through education Norman *et al.* (2005), claims that farmers may know the rationale for managing land through better farming practices and other social economic factors. The farmer's education background is an important factor that determining delay to accept and properly apply technologies (Swamson *et al*., 1984). In Tanzania most farmers have low formal education and they mostly use traditional farming practices. To use more technology, more education will play an important role to enable easily (CIMMYT, 1993).

Perception of the Farmer

Perception of the farmer plays an important role in the decision of adopting conservation agriculture. It is expected that farmers who would view such initiatives as important would accept the project at a larger extent. The possible explanation here is that farmers who perceive this innovation as beneficial to them would adopt the CA more than those whose perception is negative or indifferent (Ayuya *et al.*, 2011).

Household Income

Household income plays a role of financing to use the new innovation. Serman and Filson (1999) said that high farm income improves the capacity to adopt agricultural innovations as they have the necessary capital to start the innovation. The influence of off-farm income in the adoption of new technologies is derived from the fact that income earned can be used to finance the uptake of new innovation (Amsalu A. and De Graaff, J., 2007).

High income has a positive influence on the initial stages of trial of innovations as the wealth allows the farmer to invest a relative small proportion if their income into an uncertain enterprise (FAO., 2013). Wealthier farmers may be the first to try new technology especially if it involves purchased inputs because they are more able to take risk that is farmers who do not utilize new technology may complain the lack of cash as the principle factor limiting their utilization (CIMMYT, 1993).

Gender

Gender is also hypothesized to influence adoption. It is often that women are forgotten a lot in the case of technology adoption and transfer (CIMMYT, 1993). This is reinforced by the cultural system which requires women to remain at home while husbands attend seminars, and yet do not always teach the women what they have learnt in the extension service meetings (Morris, J., 1991). Women also do not have accessibility to the key productive resources of land, labor and capital as well as being under privileged in education and knowledge (Morris, 1991; Mazvimavi and Twomlow, 2009).

2.4.2. Institutional Factors

Access to Credit and Inputs

Access to credit is an important factor in acquiring basic inputs required for adoption of conservation farming (Feder, 1985). Credit was identified as a major factor affecting adoption for new hybrid rice technologies in Thailand (Ruttan and Thirtle, 1987). The CA techniques involve purchase of new equipment's necessary for direct planting such as fertilizer and other agro-chemicals, the high cost of farming inputs has a significant impact on cash demand of farmers during the farming season (Sanginga *et al*., 2003).

Extension Services

Extension is regarded as a process of integrating indigenous and derived knowledge, attitudes and skills determined the available to overcome particular obstacle (FAO, 2011). An extension agent's role is to provide smallholder farmer with the necessary agricultural and livestock production knowledge and skill that enable them to make rational production decision for the increasing production that ultimately improves their socio-economic status (Mlonzi M.R.S, 2005). The same source also claimed that the level of adoption of improved agricultural technologies and practices is clearly related to the quality of extension workers

Baidu-Forson (1999), found that adoption rate of farmers who having contact with extension agents working on CA technologies was higher compared to farmers who have never contact any extension agent. An effective extension system should be able to identify farmer needs and problems to determine the best possible solution (Mattee A.Z., 1994).

3. MATERIALS AND METHODS

3.1. Description of the study area

3.1.1. Location

The study was conducted in Kilite-awlaelo district which is found in the eastern zone of Tigray region. Kilte-awlaelo district is located to the north of Mekelle city at a distance of 45 km. The district is geographically located at 13^0 30' –13^0 36' N latitude and 39^0 36' 390 42’ E longitudes. It is bordered on the south by Endereta, on the north western by hawzen on the south western by degua- temben on the west by atsbi-wenberta district.

The district is administratively divided in to 20 kebelles. Out of this kebelles the study was particularly undertaken in Gemad which is found in north, Negash and Tsaeda-naele fond in the north direction of the district.

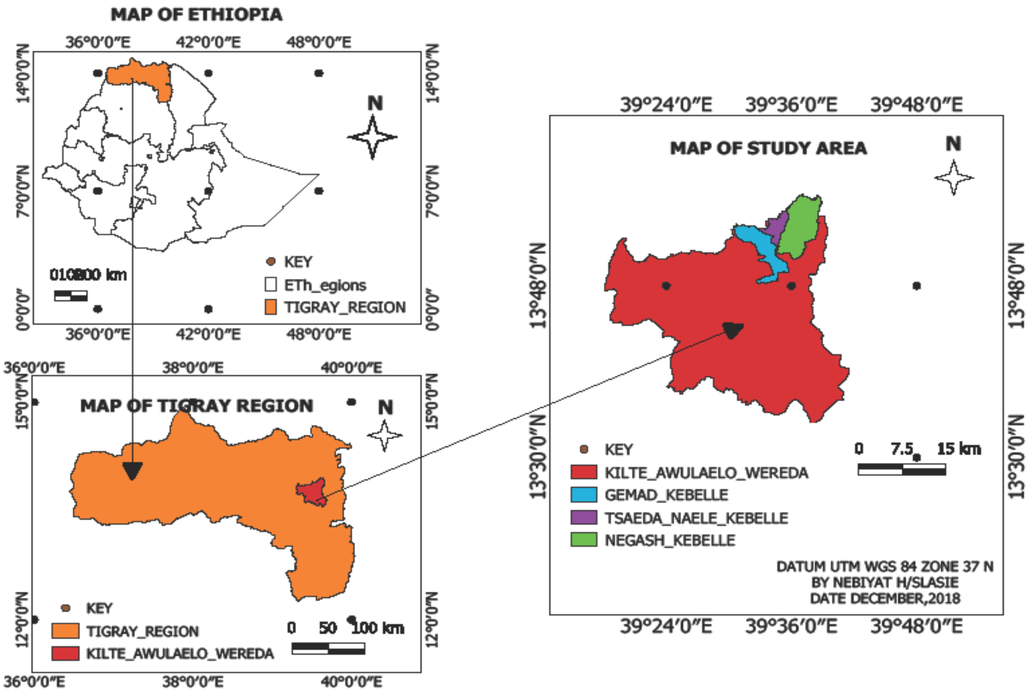

Figure 1: Map of the study area Kilte-awlaelo district

3.1.2. **Population**

Based on the 2019 population projection of the district, it has a total population of 119,772 of whom 61334 are male and 58438 are women. The total numbers of house holed heads are 21392, of this 12680 are male headed house holed, while 8712, are female –headed house hold. Out of the total number of households 13,144 are urban in habitants (WOARD, 2018).

The total area of district is about 101,758 ha (WOARD, 2018). As well as the specific study kebelles area is, Gemad (1634ha) , Teseda -naele (1768ha) and Negash (6221 ha) with having a total population 22315 and 3750 total house headed, respectively (WOARD ,2018).

3.1.3. **Climate**

The climate of kiltie - awlaelo ranges from cool to warm (WOARD, 2018). The annual average temperature of the area is 17 c^{o}- 23c^{o}. Rainfall is usually intense and short in duration, with an annual average of about 350 mm- 450 mm (WOARD, 2018) . The elevation / latitude of the study district ranges from 1500 -3200 m.a.s.l.

The climate of the area is characterized by 75% AS highland dega and 25 % as middle land Weynadega (ILRI and MOA , 2004).all the specific study sites are fond at the range of elevation (1500- 2300 m.a.s.l) Wayne-dega and the rest with Dega (2300 to 3200 m.a.s.l) climatic condition.

3.1.4. Livestock population

Livestock is the main component of the farming system of the district (ILRI and MOA, 2004). According the official report of the district (2018), it possessed 354,957 livestock population consisting of 64,419cattel, 111,655sheep, 42,902 goats, 162 horses, 781, mules, 12,432 donkeys, camels, 603 and 122,003 poultres.

3.1.5. **Resource endowment and farming system**

Agriculture is the main means of living for all in habitants of the district. The dominantly practice mixed crop –livestock farming system which depends on rain fall .how ever recently farmers adopted irrigation based on crop cultivation in same area of the district introduction of water harvesting . The major crops grown in the area is barley, wheat, teff and hanfets. According to the data of the WOARD the average size of landholding of farm house holds in the district is 0.5 hectares.

3.1.6. **Existing land use**

The land use profile study of Woreda indicates that kiltie – awlaelo district has total land coverage of 101,758 ha ,of this total area , the dominant portion is covered by forest (including area enclosure ,individually managed hillsides and community enclosed) which constitute 45.89 % ,rugged mountains and gorges (miscellaneous land) which constitute 20.14% and arable land , grazing land and settlement area for 19.47 % ,7.79 % and 6.71 % respectively.

3.1.7. **Vegetation cover**

An area closure and privately managed hillsides contributed to the regeneration of vegetation cover of the area. Trees like acacia species and shrubs of *Dodonaea angostfolia* and eucalyptus are found in the protected area .the *Eucalypts* tree is the dominant species found around the homesteads and privately manage hillsides in the district in general and in the study area.

Community members were more motivated to plant *Eucalyptus* trees than others due to the characteristic of the plant (fast growing nature, tall and straight poles, ease of establishment and market demand for construction in the district and all cover the region). At the national level, 89 % of the energy consumption goes to house hold energy demand with in households, traditional fuels such as (fuel wood , dung , and residues) have as hare of 99.6 % of the total house hold energy consumption (WBI SPP,2004) . This energy behavior is the main threat to enclosed areas of the district.

3.2. **Sampling Techniques**

The study followed multi-stage stratified random sampling techniques. In the first stage, Kilite-awlaelo was purposively selected due to wide range of Agro-ecological condition and the presence of CA activities. In the second stage, three Kebelles where more CA activates implemented were purposively (randomly) selected from the 20 Kebelles within the Woreda. In the third stage, households were stratified into two groups depending on whether they were adopters/users of CA technology or not. At the final stage, sample households were randomly selected following proportional to population Size (PPS) approach. Household samples were taken randomly by using separate lists of practitioners and non-practitioners of CA household heads. Households were sampled randomly using standard formula Yemane (1967) to determine the required sample size at 92% confidence level, and with level of precision of 8%;

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

Where ''n'' is the sample size, ''N'' no of house hold in the tree kebelles, and ''e'' is the level of precision.

The number of sample households representing the different wealth category was selected proportionally on the basis of the number of households in each Kebelles.

Accordingly, from the total 3750 HHs of the three Kebelles, an effort was made to sample 150 HHs in the study areas for entire survey. Since the numbers of farmers in each category can be different, specific numbers of respondents was selected with probability proportionate to size (PPS) random sampling technique to ensure representativeness of the population. Of the total of 150 sample respondents 74 were adopters while the rest 76 non-adopters.

Table 1: Households sample distribution

Kebelles	Total No. of house hold			Sample size taken		
	Adopter	None adopter	Total	Adopter	None adopter	Total
1Gemad	460	463	923	18	18	36
2Tsaeda-naele	533	574	1107	21	22	43
3 Negash	844	876	1720	35	36	71
Total	1837	1913	3750	74	76	150

Source: field survey, 2019

3.2.1. **Methods of Data Collection**

3.2.1.1. **Source of Data**

The study considered both primary and secondary sources of data. Secondary data sources were collected from experts of bureau of agriculture and related documents, journal article, research report and other information. Primary data was collected through a structured questionnaire, focus group discussions (FGD), key informant interviews (KI), and field observation. Secondary data were collected from Tigray Region bureau of agriculture and natural resources.

Household survey

A detailed household survey was administered between September and June in 2019 with 150 farm households. A semi-structured questionnaire was used to collect data on household characteristics (family size, household age, educational level) resource endowments (farm size, livestock availability, availability of job, income and economic class of the household) and Institutional factors (extension service and access to credit). The questionnaire was pre-tested using 10 farmers selected randomly from the three

Kebelles. The main reason for pre-testing is to carry out the necessary adjustment and corrections of the research instrument to the target respondents.

Key informant selection (KI)

In this study, KIs were referred as elder or a knowledgeable farmer who has deeper knowledge on CA component management, environmental condition and livelihood systems and lived in the area for long period of time. Elderly people, Kebelle administrative and development agents (DAs) were participated in the interview. Key informant interviewees were asked to differentiate non adopter and adopters and provided information on contribution of conservation agriculture towards climate change adaptation the mechanisms used by the household to enhance climate change adaptation. Furthermore, they were asked about the perceptions of farmers on CA and their existing condition, their management practices, its challenges. The information taken from key informants was used for triangulation of HHs surveyed data.

Focus group discussion (FGD)

Focus group discussion was conducted to generate data at community level by involving a small group of respondents with the aim to obtain the overall importance of CA for productivity, resilience and soil fertility management. In the FGD representatives from community elders, women, and youth groups were included. In each of the three study Kebelles, one FGD was made with a group of participants having 12 members which include both adopters and non-adopters of CA.

3.2.2. Methods of Data Analysis

Both the qualitative and quantitative data were analyzed using Statistical Package for Social Sciences version 20. This study used descriptive statistical research method to describe and summarize features of data quantitatively as well as descriptive research method such as observational and survey method in order to identify, determine and describe the socioeconomic (age of respondents, education level of respondents, family size, and economic class of the respondent) and institutional (Access to Credit, access to information, access to extension service) characteristics of household being studied. Analytical method also used to analyses facts or information already available to make critical evaluation

3.2.2.1. **Description of variable**

1. **Dependent variable**

To analyze factors that affect adoption of CA multivariate legit regression model was applied. The farm households' choice of multiple CA technologies was taken as a dependent variable and value of '1' was given if the household is adopter of the specific technology, and '2' otherwise. Logistic regression is a probability estimation model applied when the dependent variable is binary and the independent variable is in any form of measurement scale (Cramer, 2003).

y = a+bx………………………………………………………………………… (1)

$p = \frac{1}{1+e^{-(a+bx)}} = \frac{e^{a+bx}}{1+e^{a+bx}}$ ……………………………………………………………….(2)

Where P is the probability of the event occurring, X are the independent variables, e is the base of the natural logarithm and a, and b are the parameters to be estimated by the model. As p is the probability of choosing the multiple CA technologies, 1- p is the probability of not choosing the multiple CA technologies. Therefore

$1-p = \frac{1}{1+e^{a+bx}}$ ……………………………………………………………….………………. (3)

To obtain the odds ratio of choosing the multiple CA technologies will be

$\ln(\frac{p}{1-p}) = 1 + e^{-(a+bx)} = a + bx$ ………………………………………….…………………. (4)

The logistic prediction equation or multiple variables the equation will be as follows

$$\ln\left(\frac{p}{1-p}\right) = \beta o + \beta 1X1 + \beta 2X2 + \cdots + \beta iXi + \varepsilon i \text{ ………………………………………. (5)}$$

Where Y= choosing the multiple CA technologies (dependent variable)

β0= constant (coefficient of intercept)

β1, β2, βi = parameters to be estimated

X1 X2 …. Xi = the explanatory variables to fitted into the model that is, the various household, socio-economic, demographic, institutional, and related factors that affect choice of multiple Conservation Agriculture technology may be of continuous, categorical or dummy nature (Long and Freese, 2006).

2. Independent variable and Expected impact on adoption

Table 2: Description of explanatory variables and their measurements

Variables	Type	Measurements	Expected sign
Sex of the HH	Dummy	1 male, 2 female	Positive/+
Age of the HH	Categorical	1 =18-35 years old, 2 = 35-65 years old and 3 = greater than 65 years old	Negative/-
Family Size	Categorical	1 =1-3, 2 = 4-7 and 3 = greater than 8	Positive/+
Educational Level	Dummy	1, illiteracy, 2, Literate	Positive/+
Availability of job	Dummy	1 if the HH have job, 2 otherwise	Positive/+
Land holding	Dummy	1 if the HH have land, 2 otherwise	Positive/+
Economic class of HH	Continuous	1, rich, 2 medium, 3, Poor, 4, poorest of the poor	Positive/+
Availably of Livestock	Dummy	1 if the HH have livestock, 2 otherwise	Positive/+
Extension service	Dummy	1 if the HH get extension service, 2 otherwise	Positive/+
Participation on training	Dummy	1 if the HH participate in training, 2 otherwise	Positive/+
Access to credit	Dummy	1 if the HH have access to credit, 2 otherwise	Positive/+
Adoption of CA by the HH	Dummy	1 if the HH have adopt CA, 2 otherwise	Positive/+

Source: Field survey,2019

3.2.3. Definition of Variables and Hypotheses

The following explanatory variables were hypothesized to influence the roles and contribution of CA in the study area.

Household sex:- This is a dummy variable, which takes 1 if sex of respondent is male, 2 otherwise. Since the participation of women both on farm and off farm activities are by far limited due to cultural impediments than male, female headed households are expected to be less participated in CA adoption and benefited from the technology than male headed households.

Farmer's age:- It is measured in number of years. Age of a farmer can generate or erode confidence on technologies. In other words, with age a farmer can become more risk averse to new technologies. However there are mixed results as to the direction of influence. It was hypothesized that younger farmers have more probability of adopting CA technologies.

Education:- Level of education was assumed to increase farmers' ability to obtain, process, and use information relevant to the adoption of conservation agriculture. Education is therefore expected to increase the probability of adoption the technology. It is measured as a binary variable: 1, if the farmer is illiterate and 2 literate.

Family Size:- family size was assumed to increase farmers' ability to adopt conservation agriculture. Family size is therefore expected to increase the probability of adoption the technology. It is measured as a catagory variable: 1, 2 if the farmers have less than has 4-7 family size and 3 if the farmer has greater than 8 family sizes.

Contacts with extension agents:- contact with DA's are more likely to be aware of new practices as they are easily exposed to information (Habtemariam Abate, 2004) the variable was dummy, which takes a value of 1 if the household received extension service and zero, otherwise. The variable represents extension service as an important source of information, knowledge and advice to small holder farmers in Ethiopia. Empirical results revealed that extension contact has an influence on farm households' adoption of new technology (Mlonzi, 2005). Following this argument, extension contact was hypothesized, in this study, to influence farmers' decision to adopt CA and contribute to the life of the respondents.

Economic class of the respondent:- This refers to economic condition of the respondent and it is a categorical variable. That is, 1, if the respondent is rich, 2 if the respondent is medium, 3, if the respondent is poor, and 4, if the respondent is poorest of the poor. Hence, it was hypothesized to affect adoption of CA technologies positively.

Attending in training:- Training is one of the means by which farmers acquire new knowledge and skill and it is measured in terms of the number of times the farmer has participated. Hence, participation in training is expected to positively influence farmers' adoption behavior.

Access to Credit:- It is measured in terms of whether respondents have access to credit interims of availability of credit sources and possibility of getting credit. Farmers who have access to credit may overcome their financial constraints and therefore buy inputs. Farmers without cash and no access to credit will find it very difficult to attain and adopt new technologies (Mlonzi, 2005). It is expected that access to credit will increase the probability of adopting CA technologies.

Participation in non-farm activities:- Additional income earned from agricultural activities outside the farm increases the farmers' financial capacity and increases the probability of investing on new technologies (Habtemariam Abate, 2004). Therefore, it is expected to affect adoption positively. It is treated as a dummy variable taking 1 if a household head participated in non-farm income generating activities; 2, otherwise.

Information access:- it was measured in terms of frequency of contact with different media (TV, radio, print). Mass media play the greatest role in creating awareness in shortest time possible over large area of coverage. As far as awareness is prerequisite for behavioral change its role cannot be underestimated. It is expected to have positive influence on CA adoption. Radio was the only mass media used by respondents in the study area and hence frequency of contact with radio was taken as the only variable to show mass media exposure of farmers in the study area.

4. RESULTS AND DISCUSSION

4.1. Households' Characteristics And CA Adopters

Household characteristics are those variables that explain information about the household such as respondent's gender, age, family size, marital status, level of education and economic class. Among the total of 150 respondents, 70% of them were male headed households while the rest 30% were female household headed. 17 of CA adopters were female household head while the rest 57 was male headed households and the same is true for non-adopters (Table 3). About three-fourth of CA adopters and more than half of non-adopters were between 35-65 age categories. Slightly higher respondents (18.4%) of non-adopters were in the age category of greater than 65 years than the CA adopters (17.6 %). This implies that the majority of CA adopters were adult which is basic for decision-making on technology adoption and other agricultural activities. This study is similar to Harford (2009), who argued that, an increase in age, farmers tend to reject new farming practices for less demanding coping systems with low transitional cost associated with them. More CA adopters had access to extension and credit services than the non-adopters (Table 3). This study is similar to Baidu-forson (1999), who found that adoption rate of farmers who having contact with extension agents working on CA technologies was higher compared to farmers who have never contact any extension agent. Besides, Mlonzi (2005) claimed that the level of adoption of improved agricultural technologies and practices is clearly related to the quality of extension workers. In addition, this finding is similar to Feder *et al*. (1985), who found that, access to credit is an important factor in acquiring basic inputs required for adoption of conservation farming.

Table 3: Socioeconomic and demographic characteristics of respondents

Variable	Category	Respondents	Adoption			
			Adopter	%	Non-adopter	%
Sex	Female(2)	45	17	23	28	36.8
	Male(1)	105	57	77	48	63.2
	Total	150	74	100	76	100
Age	18-35	29	8	10.8	21	27.6
	35-65	94	53	71.6	41	54
	>65	27	13	17.6	14	18.4
marital status	Single(1)	2	1	1.4	1	1.3
	Married (2)	103	55	74.3	48	63.2
	Widowed (3)	22	10	13.5	12	15.8
	Divorced (4)	23	8	10.8	15	19.7
Economic class of Respondents	Rich	29	24	32.4	5	6.6
	Medium	81	43	58.1	38	50
	Poor	39	7	9.5	32	42.1
	Poorest of the poor	1	0	0	1	1.3
Extension service	Access	96	61	82.4	35	41.1
	No Access	54	13	17.6	41	49.9
Credit institutions	Access	96	59	79.7	37	51.3
	No Access	54	15	20.3	39	48.7

Source: Own survey data ,2019

4.1.1. Family size

Family size is an engine for farming community as they are the main sources of labour for agricultural related activities. In this study family size were categorized into three based on their labour contribution to agriculture. The smallest (5.4%) respondents had 1-3 family members, while the largest (59.5%) had 4-7 family members (Fig 2). About 35.1% of them had a family member more than 8. The majority of both adopters and non-adopters had a family member between 4 and 7. Similarly, Ayuya *et al.* (2011) reported that the importance of larger family member in relaxing the labor constraints required during peak period. More adopters had a family size of more than 8 family members compared to the non-adopters.

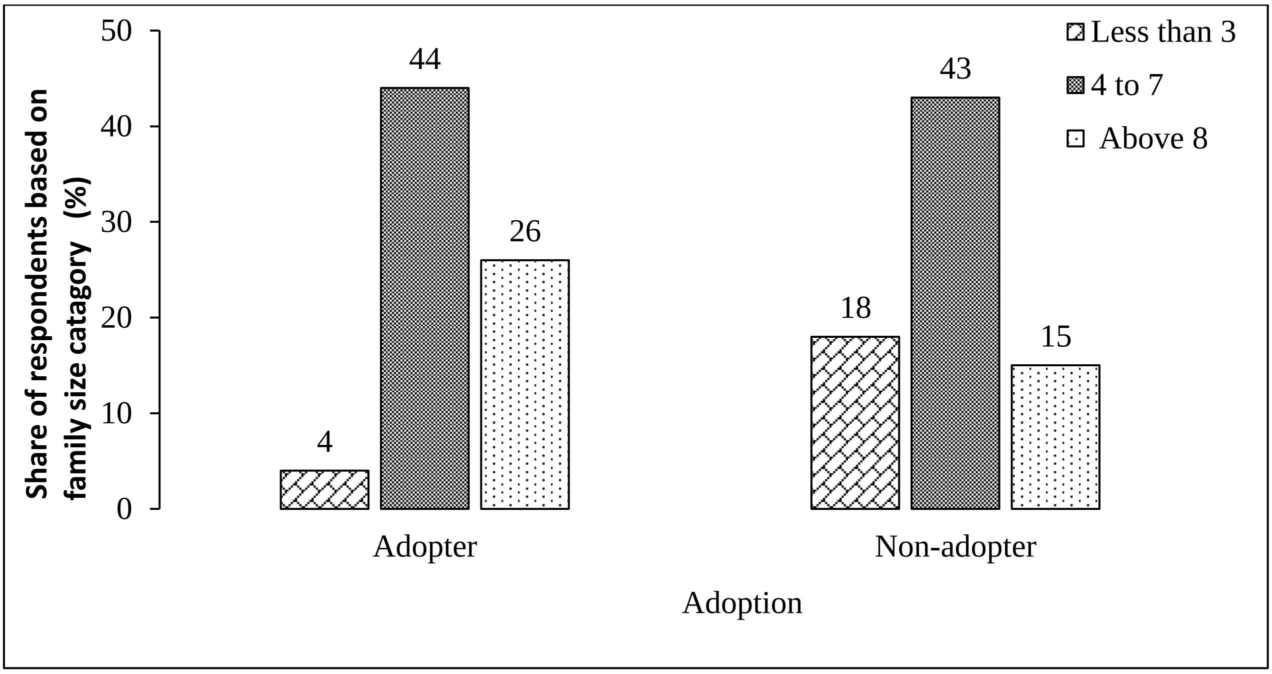

Figure 2: Category of family size for adopters and non-adopters of CA in the study area

4.1.2. Educational Status of CA adopters and non–adopter

The majority of non-adopters (55.3%) did not attend any school while the reverse is true for CA adopters (Fig 3). Conservation agriculture adopters were more educated than non-adopters. This implies that education had positive implication for technology adoption in the study area. This study is similar to previous works of Swamson *et al.* (1984), that found the farmer's education background is an important factor that determining the readiness to accept and properly apply technologies. This study also came up with similar findings of CIMMYT, (1993), in Tanzania most farmers have low formal education and they mostly use traditional farming practices; the more complex the technology to be utilized the more likely it is the education will play the major role.

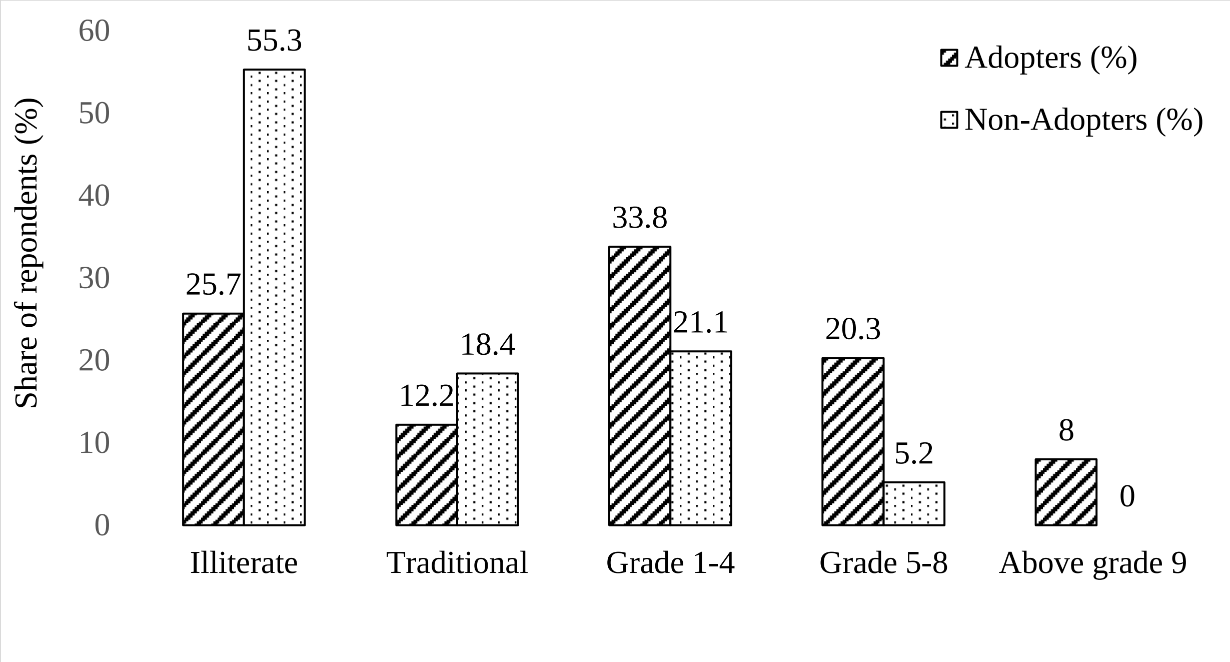

Figure 3: Educational level of respondents in the study area

4.2. Types of Conservation Agriculture Practiced in Kilite-awlaelo District

The result in table 4 below reveals that fifty percent of the respondents practice crop rotation and intercropping as a means of climate smart agriculture so as to improve product and productivity while, 41.9% of them practiced crop residue, compost and manure application as a CA practice. This finding is not in line with the report of FAO (2016), which indicated limited practices of CA in Ethiopia. Indeed the FAO (2016), report was in line with the practiced of minimum tillage as vary only 4% of the respondents practice CA in the study area. Respondents replied that the use of intercropping has positive effect on soil fertility enrichment, reducing disease infestation and producing multiple out-put per year. Similarly, the importance of intercropping practices for reducing the risk of pest and weed infestations; better distribution of water and nutrients through the soil profile; use of nutrients from different strata of root depth were explained during focus group discussion.

The idea of FGDs was similar with FAO (2001), as justified that the importance of intercropping and crop rotation for diverse "diet" to the soil microorganisms, the possibility of exploiting nutrients from deep soil in the forms of root differentiations were reported.

Table 4: Types of conservation agriculture adopted as means of climate smart agriculture (n=74)

Types of CA Practiced	Adopter HHs	%
Intercropping and crop rotation	37	50
Crop residue, compost and manure application	31	41.9
Minimum Tillage / reduced tillage	4	5.4
Boundary agroforestry practice	2	2.7

During the FGD the participants replied that leaving crop residue in the field and application of organic matter such as manure is also widely applied in the study area to improve the soil fertility and texture. This result is supported to the idea reported by Tolesa D (2001), as the role of adding organic matter to the soil up to 35% is acknowledged for reducing erosion up of 85 %. Although the application of minimum tillage is practiced by very small farmers, it is acknowledged for enhanced water infiltration and reduced risk of erosion.

4.2.1. Justification of Types Conservation Agriculture Practices in the Study Area

According the experience of the adopters, intercropping is implemented mixing maize with peagen-pea and teff with tomato. Again in terms of the respondents crop rotation is one of the conservation agriculture practices mostly happened when a farm land is covered with different Varity in different season. This means that when wheat is sowing at current and changed with maize in the coming year and again covered with legume crops in the next year in recycling manner.

Respondents regularly made due to the importance of these practices include reduced risk of pest and weed infestations; better distribution of water and nutrients through the soil profile; exploration for nutrients and water of diverse strata of the soil profile by roots of many different plant species, resulting in a greater use of the available nutrients and water. Crop rotation is not only necessary to offer a diverse "diet" to the soil microorganisms, but as they root at different soil depths, they are capable of exploring different soil layers for nutrients (FAO, 2001). Nutrients that have been leached to deeper layers and that are no longer available for the commercial crop can be "recycled" by the crops in rotation, this way the rotation crops function as biological pumps. Furthermore, a diversity of crops in rotation leads to a diverse soil flora and fauna, as the roots excrete different organic substances that attract different types of bacteria and fungi, which in turn, play an important role in the transformation of these substances into plant available nutrients (FAO, 2001; ACT, 2008).

In the other way, the success of conservation agriculture in the study area is highly dependent on crop residue, compost and manure management. Application of crop residues, compost and manure provide protective cover for the soil and increase soil infiltration. This justification is similar with the study of Tolesa D (2001), has shown that when 35% of the soil surface is covered with uniformly distributed residues, splash erosion will be reduced by up to 85 %. Approximately two tons of maize residues per hectare are necessary to obtain 35% soil cover, which has been established as the minimum amount required for achieving a substantial reduction in relative soil erosion. However, in the study area, crop residues have traditionally been used for multiple purposes, like animal feed, used fire wood for cooking, and building materials, which conflict with their use in conservation agriculture. Among these, use of crop residue as livestock-feed and cow dang as fire wood is probably the most widespread in the study area.

Land preparation in the study area is mainly carried out with a view of getting rid of weeds and improves water infiltration, through breaking compacted soils. However, moisture infiltration is much better in soils that are less tilled but not compacted by the effect of overgrazing. Conservation agriculture using reduced tillage in the study area has been demonstrated for five years on some serials, oil seeds, and vegetables; like wheat, flax, chickpea, and onion has been shown successful results.

4.3. Role and Contribution of CA for Climate Change Adaptation

The result in table 5 indicates that 86.5% of the respondents acknowledged the role of CA for climate change adaptation while, 13.5% of them were not clear on its positive or negative effect of CA when, the long term and short-term contribution of CA for climate change adaptation were discussed. According to group discussions the reason of CA adoption in the area was due to the recurrent droughts, erratic nature of rain fall which reduced agricultural production and productivity and resulting openness of climatic shocks they face. Given the steep slopes of their fields, conservation agriculture has a great impact in reducing soil erosion and increased rainwater infiltration and build-up of soil organic matter which is vital for crop productivity.

Table 5: Overalls contribution of conservation agriculture to climate change adaptation

Contribution of conservation agriculture on the life of households						Total
	Positive contribution with long term change	Positive contribution with temporary benefit	Very small positive change	partly positive, partly negative	negative contribution	
Number of Farmers	39	20	5	10	0	74
(%)	52.7	27	6.8	13.5	0	100

Based on the above qualitative data the different positive effects of CA are summarized as follows. The role CA for soil fertility improvements are explained by the input of organic matter into the soil and reduced erosion and nutrient mining. This finding is similar to Hobbs *et al*.(2007), as justified that CA is a technology that conserves, improves and efficiently utilizes resources through integrated management of available resources combined with external inputs. The importance of CA for water availability improvement is explained by the soil fertility enrichment as an increase in soil organic carbon that makes to enhance water holding capacity of the soil. The overall improvement in soil fertility and water holding capacity of the soil is vital for obtaining higher crop and livestock productivity that become food secure. In general, the KIs and FGDS have indicated that conservation agriculture helps them as a coping strategy to climate change adaptation (plate 4). Particularly, CA adopters were more aware of the role of CA for reducing soil erosion and better crop production compared to non-adopters. This result is similar with the studies reported by Derpsch (2005), revealed that the importance of conservation agriculture is used for improving soil fertility, soil organic matter and for increasing rain water infiltration.

Plate 4: Focus group discussion

4.4. Determinants of Conservation Agriculture for Adoption to Climate Change

To identify and understand the determinants of CA adaptation as a means of climate change adaptation was assessed using binary logistic model. The analysis result indicated that education level, access to extension, access to credit and had significantly positive effect on adoption of CA, while off-farm activity had significantly negative effect (Table 6). The probability of adopting CA by educated farmers was 10.965 times higher than the uneducated ones. This is related to the fact that educated people tend to easily understand and accept new technologies compared to uneducated ones. This study is similar to previous works of Swamson *et al.* (1984) who reported the positive effect of education on technology adoption. Similarly, the positive effect of education of technology adoption was reported on the study conducted in Tanzania CIMMYT (1993).

Table 6: Variables determine CA adaptation for climate change adoption

Variables	B	S.E.	Wald	Sig.	Exp(B)
Literacy	2.395	.594	16.254	.000***	10.965
Family size	-.758	.431	3.103	.078	.468
Access to extension	1.044	.530	3.879	.049**	2.840
Access to credit	2.149	.592	13.184	.000***	8.572
Sex of HH	.139	.609	.052	.820	1.149
Off-farm activity	-2.897	.558	27.005	.000***	.055
Constant	-1.620	1.817	.796	.024	.198

Note: ***, ** shows statically significant at 0.01, 5, and 1% level of probability

Access to extension had significantly positive effect on CA adaptation with odd ratio of 2.840. This implies that farmers who had access to extension adapt CA technologies 2.80 times more than those who do not have access to extension services. This finding is consistent with Baidu-forson (1999) who reported that the positive effects of extension service for conservation agriculture adoption. Furthermore, the role of effective extension on identifying farmers' problem and suggest suitable development options were reported elsewhere (Mattee, 1994).

Similarly, access to credit had significant positive effect on farmers' CA adoption decision with odd ratio of 8.572 and marginal effect/slop/ of 2.149 (Table 6). This odd ratio indicate that CA adoption probability for a household that get access to credit is 8.572 times higher than a household that did not Feder (1985) get access to credit. As it was expected getting access to credit by the household was positively related to CA adoption decision. This finding is similar with the study by Ruttan and Thirtle in Thailand (1987), who reported access to credit as an important factor in acquiring basic inputs required for adoption of conservation farming. Similarly, Ruttan and Thirtle in Thailand (1987) reported the positive effect of access to credit on adoption of new hybrid rice technologies and other studies who reported the positive effect of access to credit on CA adoption and purchasing of new equipment required for agriculture (Adjei *et al*., 2003).

However, engagement of the farmers in non-farm activity had a significant negative effect on CA adoption decision with marginal effect/slop/ of -2.897. This implies that the probability of adopting CA by those who engaged in off-farm activities decrease 0.055 times than those who fully engaged in farm activities. As it was expected farmers engagement in non-farm activity has negatively related with CA adoption decision. This finding has deviated from the finding of Amsalu and De Jan (2007), who reported a positive relation between off-farm engagement and adoption of new technologies.

4.5. **Level of Perception of Farmers to Ward Climate Variability**

The focus group discussants noticed that CA contributed to increase their crops yield through reducing erosion from their farm land. The main reason as the justification of the respondents were CA improved the quality of the crop by having knowledge how to avoid herbicides and developing the knowledge of integrated pest management on each individual of their farm lands. The study further investigated why some farmers adopt CA, others not. The main reason as the clarification of the respondents were labour intensiveness, lack of training, and lack of capital to invest in technologies were the main constraints for farmers not to adopt in their respective farm land in the study area. In addition to this, lack of training, poverty, and land owner ship were the main reasons for farmers not to adopt CA technologies. Farmers are hesitant to invest in labour for technologies such as large pits and terraces on hired farms that they are not sure of continuing to form subsequent season. From the field observation the other reasons of non-adopters that made them to be less in practice due to lack of interest to done the types of CA. Such as lack of intensives and time constraints were also other reasons. In addition to this the shortage of farm inputs, costly implements, low returns, and lack of land implanting technologies were also reasons mentioned by farmers.

The reasons for positive perception among farmers were related to increase in crop yields and better utilization of labour and time for farm operations were also replied by most of the farmers.

4.5.1. Perception of local community on the impacts of the climate variability

Discussants from FGD and KIS have revealed that climate variability impact exposed people fall in to poverty. Eighty five percent of the farmers said that interacts with existing problem and makes them worse. In this study, the whole 150 respondents said that there is climate variability in the area. The respondents explained that they face recurrent drought s and intensive heat waves from increasing temperature. The FGD s indicated that short rain season results in reduced agricultural yields is already highly fragmented land scopes and increased climatic shocks promotes fuel conflict over access to natural resources like water and grasses.

4.5.2. Challenges of climate variability

KIs have identified changes in temperature, rain fall, soil moisture, stream discharges, and humidity as relevant indicators of climate variability in the study area. Respondents of the house hold survey also identified an increase in temperature, leading to changing agro-ecological characterstics, drying and disappearance of fodder species as indicators. In terms of changes in rainfall, respondents identified increase availability in the rain fall pattern, which includes changes in timing, intensity and duration of rain fall.

FGDs were also identified as contributing to decrease soil moisture content, which in turn has resulted in early disappearance of fodder species. In addition to this, KIS also specified in their discussion that they get rain fall twice in a year, short heavy rain season which delays between July to August and the light locally known as Belgi ran fall is between May to June. In relation to humidity, respondents across study site indicate that the air is getting dryer. Respondents replied that in the highlands of the district there has been an increase in the frequency of famine and droughts this last ten years. Extreme heat and short rain fall were mentioned as major climate variability related problems in the district. Especially, temperature is high in the district. So the minimum temperature increase has negative impacts. It was explained that temperature in the study area some times, exceeds the threshold, which livestock, crop, and humans cope. The communities in the sample area also maintained the replacement grass species by bush encroachment is aggregative by varying climate in the study area. According to the discussion with KIS, the shortening and patchy rain fall distribution has resulted in an alarming replacement of palatable and nutritional important grazing   and browsing species with woody and un-palatable once.

4.5.3. **Meteorological climate data analysis**

4.5.3.1. **Annual rainfall trend:**

Annual rainfall of the study area ranged between 306.7 mm and 857.3 mm were observed in 2009 and 2001 respectively. Figure 5, shows inter-annual variability of annual rainfall over the last 30 years. The inter-annual distribution of rainfall showed that annual amounts were below the average (566.3 mm) for most years. According to Hare (2003), CV is used to classify the degree of variability of rainfall events as less (CV < 20), moderate (20 < CV < 30), and high (CV > 30). In this study, the value of coefficient variability was 17.8 which were grouped as less degree of variability in rain fall events (CV < 20).

Table 7: Descriptive statistics of annual rainfall in Kilteawlaelo district (1989-20118)

Number of years	Minimum (mm)	Observed year	Maximum (mm)	Observed year	Mean (mm)	SD	CV
30	306.7	2009	857.3	2001	566.3	100.7	17.8

Source: NMM (2018) analysis by the Author.

The analysis of a linear trend showed that the amount of annual rainfall had decreased between 1989 and 2018. It had decreased by 4.4 mm per year over the past three decades with interring annual variability in a cumulative effect.

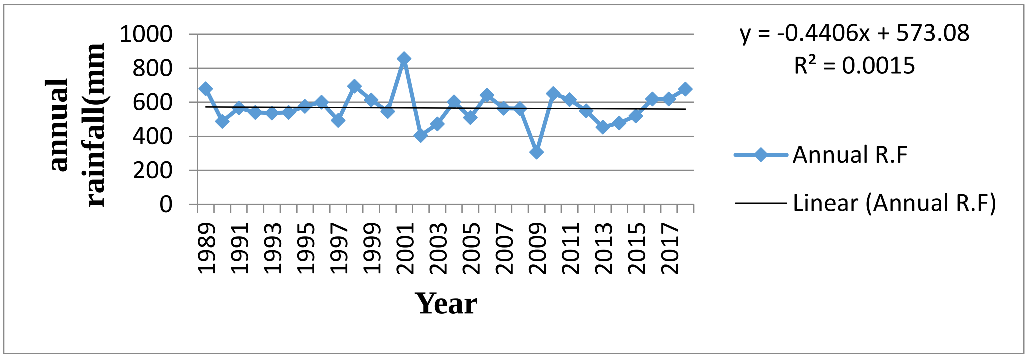

Figure 5: Annual rainfall trend in the Kilteawlaelo Woreda for 1989-2018.

Seasonal rain fall trends of the study area;

There was inter annual variability in the three seasons, summer or kiremet (June - August mainly a rainy season), autumn or Meher (September- November) and winter (Bega) which is long dry season (December-May). In summer season, the rain fall trend shows an increasing trend, however, in autumn (14.3 mm) and winter (14.6 mm) showed a decreasing trend during the last three decades.

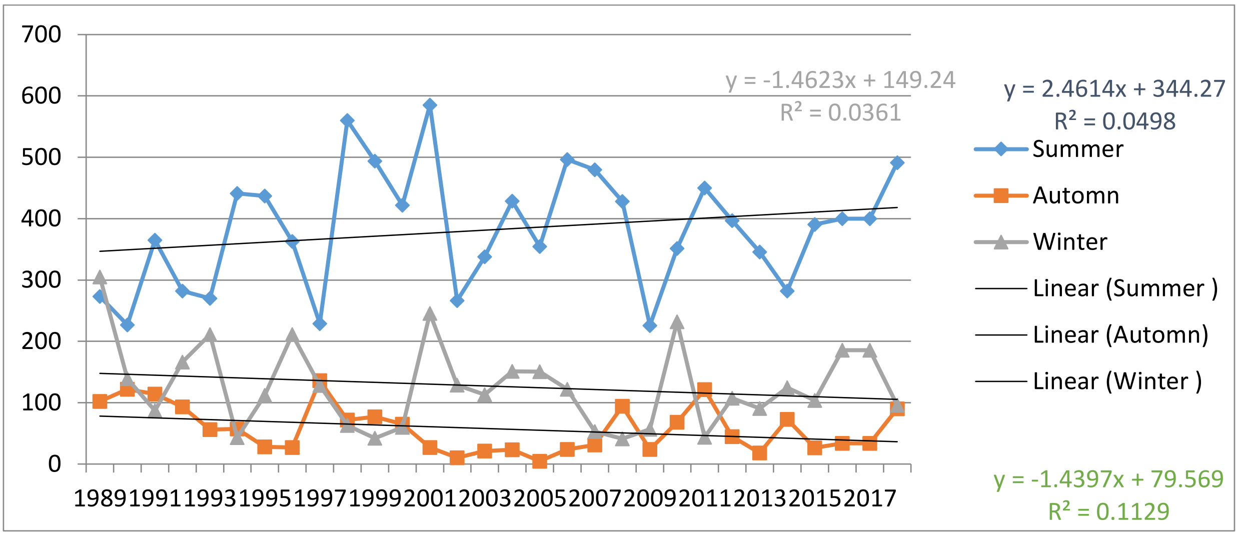

Figure 6: Seasonal rainfall trend and variability in Kilteawlaelo district for 1989 -2018

As it is shown in Table 7, coefficients of variations were 17.8%, 26.8%, 68.2% and 56.6% for the annual, summer, autumn and winter respectively. This indicates there was high inter annual variability of rain fall between 1989 and 2018. Degree of variation in amount rain fall was higher for summer, autumn, and winter seasons (CV > 20) than annual (CV< 20).

Table 8 Coefficient variation of seasonal rain fall at Kilte-awlaelo district (1989 - 2018)

Rain fall	Mean (mm)	SD	Cv (%)
Annual	306.7	100.7	17.8
Autumn	58.1	39.6	68.2
Summer	383.9	102.9	26.8
Winter	129.5	73.3	56.6

Source: Computed from the data obtained from NMM (2018).

Temperature trend:

According to Mc Sweeney *et al*. (2010) the mean annual temperature in Ethiopia has been raised by about 1.3°C, an average rate of 0.28°C per decade between 1960 and 2006. As the above Figure shown both maximum and minimum temperatures increased and there was little variability of temperature from one year to the other. The average maximum and minimum temperature was increased by 0.08 °C and 0.07 °C respectively, per decade between 1989 and 2018. Based on analysis result of meteorological data and literature, it is possible to conclude that, increased temperature and rainfall variability with frequent drought create favorable condition for pests and disease which lead to loss of agricultural production as well as water stress in which, this aggravated loss of Livestock production and deaths**.**

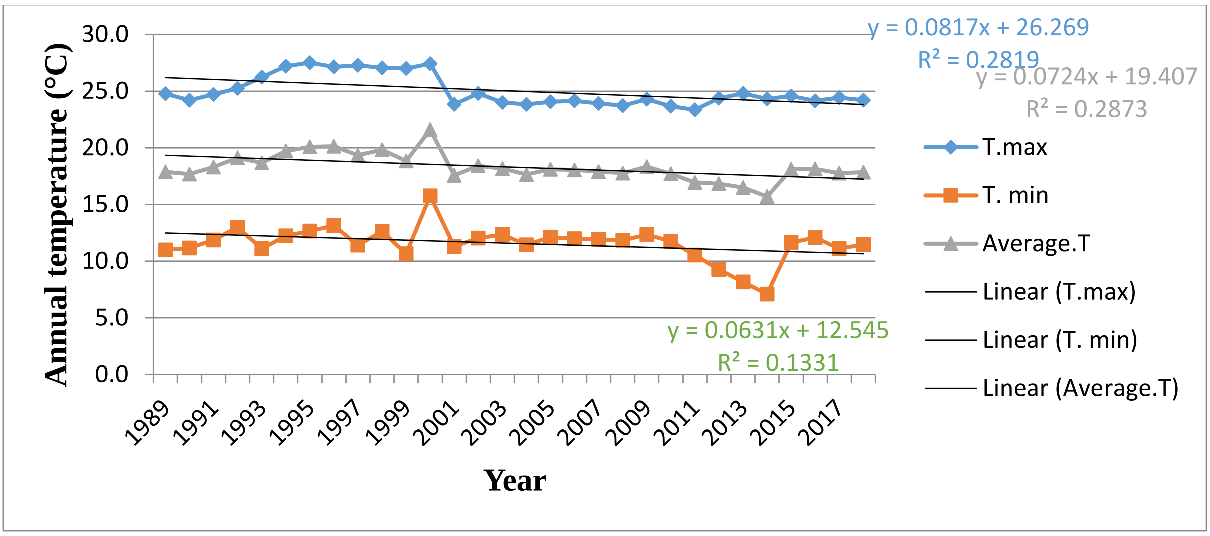

Figure 7: Temperature trend at Kilte-awlaelo district (1989-2018)

5. CONCUILSIONS AND RECOMONDUTIONS

5.1. Conclusions

Although the CA users and non-users have the same agro-ecological topographic pattern, studying the contribution of conservation agriculture (CA) practice including inter-cropping, Crop rotation, Crop residue, compost and manure application, and minimum tillage information is more important to know as a resilient to climate variation. Hence, the result shows that:-

Intercropping and crop rotation were more practiced as a means of CA to achieve climate-smart agriculture. Besides, crop residue, composting, and manure application also existed in the study area. However, the application of minimum tillage is practiced by few farmers but it is accepted by enhanced water infiltration and reduced risk of erosion.

The reason of CA adoption in the area was due to the recurrent droughts, erratic nature of rain fall which reduced production and productivity, and resulting openness of climatic shocks they face. However, the accessible of conservation agriculture in the study area has a significant impact in reducing soil erosion and increased rainwater infiltration and build-up of soil organic matter which is vital for crop productivity. Hence, the life style (livelihood) of the residents in the Woreda has become tolerant to the challenge of climatic effect.

Farmers who participated in CA practices have positively influenced by the climatic adaptation activities while off-farm activity has negative effect on the CA practices. Since, it delays to invest their time to achieve the production improvement activities.

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5.2. **Recommendation**

In the study area peasants who practice conservation agriculture has best awareness climatic stress minimization process through obtaining better service extension service whereas, non-adopters not as much as the adopters. Thus, demonstrates huge difference in the life style. Therefore, based on the findings of this study the following general recommendations are provided as follows:

- Scaling-up of the practices of conservation agriculture and creating additional access through integrated investment on CA is important to increase climatic change adaptation and hence, improve household's safety.
- All concerned stakeholders should focus on building technical and practical capacity of extension staff and farmers and efficient dissemination of knowledge to improve conservation agricultural practices and to improve CA knowledge transfer.
- Infrastructures like all whether road, training centers and access of credit systems in rural areas should be in place with a minim interest for purchase of input and low cost technologies.
- The government and concerned stakeholders need to focus on promoting organic fertilizer like manure and compost and allow investors to involve in agricultural inputs and service delivery that promote CA.
- It is very important to harmonize the different department programs and giving strong attention to design polices and strategies that address problems associated with climate change adaptation based CA principles.

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APPENDIX-I
Annex -A- Household survey questionnaire

HAWASSA UNIVERSITY

WONDO WONDOGENET COLLEGE OF FORESTRY AND NATURAL RESOURSE

CONTRIBUTION OF CONSERVATION AGRICULTURE FOR CLIMATE CHANGE ADAPTATION, THE CASE OF KILITEAWLAELO WOREDA, EASTERN TIGRAY, ETHIOPIA

SUMMARY OF SURVEY QUESTIONNAIRE

INTRODUCTION

- Introduce yourself and get introduced with the respondent
- Tell to the respondent about the purpose of the study
- Check that all questions are asked and responses are filled accordingly

1. GEOGRAPHIC AND ADMINSTRATIVE INFORMATION

Region: ______________________________Zone: ______________________________

Wereda: ____________________________Tabia /PA: __________________________

Agro-ecology of the PA: 1 = kola 2= Woynadega 3= Wurch

Name and code of Enumerator /Interviewer____________________

1. BASIC HOUSEHOLD INFORMATION/ CHARACTERISTICS

1.1 Name and code of interviewee (preferably HH Head)_______________

1.2 Sex of HH head (mark one) 1= male 2= female

1.3 Age of the HH Head ________years

1.4 Religion of the HH Head **(circle one)**

1= Orthodox 2= Muslim 3= Protestant 4= Catholic 5= Others (Specify) ________

2.5 Marital status of the household head

1= Single 2= Married 3= Widow 4= Divorced

2.6 Can you read/write? (Circle one) 1. Yes 2. No

2.7 If your answer for number 2.6 is 'Yes' where do you put yourself?

1= Traditional education (eg. ye kes tmrt) 2= Grade 1 – 4

3= Grade 5 – 8 4= Grade 9 – 10 5= Grade 11-12 6= Above Grade 12

2.8 Family Size

Type	Age group			
	< 7 yr	7-14 yrs	15-64yrs	>64yr
Male				
Female				

3. Socio-economic characteristics

3.1 Do you have a job? 1= Yes 2= No

3.2 If your answer for number 3.1 is 'Yes' what is the Major job/occupations of the Household Head:

1= Farming 2= Weaving 3= Petty Trading

4= Carpentry 5= Black Smith 6= Daily Labour 7= Pottery 8= others/specify__________

3.3 Do you or any member of your family engage in any Non-farm Activity?

1= Yes 2= No

3.4 Economic class to which the household belong

1= Rich 2= Medium 3= Poor 4= Poorest of the Poor

3.5 Do you own land? 1= Yes 2= No

3.6 If your answer for number 3.5 is 'Yes' What total size of land do you own?

Less than 0.125	0.12 5- 0.5 ha	0.5-0.75ha	0.75-1ha	1-2ha	Greater than 2ha

3.7 What type of crop do you grow in the land?

Variables	Crop type					
	Maize	Teff	Wheat	barley	Beans	Others (specify)
Area (ha)						
Yield (kg/qt)						

3.7 Do you or any other member of your household practice conservation agriculture?

1= Yes 2= No

3.8 If Yes to Question 3.7, what type of conservation agriculture do you practice?

1= The use of mulching or cover crops

2= Zero or minimum tillage

3= Combining different plants by intercropping or rotation

4= Specify if any other ____

3.9 If Yes to Question 3.7, who is responsible to CA practices?

1= Entire family 2=. Community 3= Other/specify_____________

3.10 How do you compare existing production (using CA) and with that of not used CA?

1= Increased 2= Decreased 3= No change

3.11 If your answer to Question 3.10 is increased, how much could be the increase?

1= 5 - 25% 2= 26 – 50% 3= 51 – 75% 4= 76% and above

3.12 If your answer to question 3.7 is No, what could be the reasons which make him/her not to use? And could you prioritize in order the reasons? 1st, 2nd, 3rd, 4th…

Problems					
Sufficient rain and moisture	Lack of extension service	Lack of experience	Not commonly used technology	Traditional believes	Other specify

4. LIVESTOCK

4	**Livestock**	
4.1	type of livestock	No
4.2	cattle	
43	chickens	
44	goats	
4.5	Sheep	
4.6	camels	
4.7	donkeys	
4.8	mules/ horses	

5. HOUSEHOLD INCOME

5.1 Do you generate income? 1= Yes   2= No

5.2 If yes to 5.1, what is your main source of income and please mention the amount of income

Source of income	Income in birr	Remark
Crops		
Livestock		
Trees		
Fruits		
Vegetable		
Off farm		

5.3 Is your income improving year after year? 1= Yes 2= No

5.4 If yes to 5.3, what could be the three potential reason which makes your income to improve?

1. ______________________________________
2. ______________________________________
3. ______________________________________

5.5 What happened to your household's living condition over the last three years?

1/Big improvement   2/.Small improvement

3/ Remained the same (No change)   4/ Worsening (going from bad to worse)

6. AGRICULTURAL EXTENSION SERVICES

6.1 Has your household received extension service from any government and/ NGOs?

1= Yes   2= No

6.2 Is there development agent in your village? 1= Yes 2= No

6.3 If yes to question 6.2, has he/she visited your farm? 1= Yes 2= No

6.4 If yes to question 6.3, how frequent the DA visited you _______________?

1) Never 2) every six month

3) Quarterly 4) every month

5) Every two weeks 6) Other _______________

6.5 Have you get training on conservation agriculture?

1= Yes 2= No

6.6 If yes to question 6.5, how frequent it is?

1) One's a year 2) every six month

3) Quarterly 4) every month

5) Every two weeks 6) Other (specify) ______________

7. ACCESSIBILITY TO OTHER SERVICES

7.1 Do you get market information about prices and demand conditions of agricultural inputs and out puts? 1= Yes 2= No

7.2 If yes to 9.1, indicate the sources of information ________________________________

7.3 How long does it take you access the main road from home? _________________(Hr)

7.4 Do you have access to market? 1= Yes 2= No

7.5 If yes to 9.4, how long does it take you to the main market place from home? ____(Hr)

7.6 Did you need credit for the production of your agricultural product?

1= Yes 2= No

7.7 If yes, did you have access to credit for the production of the Commodities?

1= Yes 2= No

7.8 If yes to question 7.7, what is the source of your Credit?

1 = Banks 2 = Friends/relatives

3 = Traders 4 = Microfinance

7.9 Is credit timely and adequately available for agricultural commodities development?

1= Yes 2= No

8. OVERALL ASSESSMENT AND CONTRIBUTION FOR CONSERVATION AGRICULTURE USERS

10.1 What can you say about the contribution of CA on your household's life? /Circle one/

1. Very big positive contribution (i.e., long term and permanent positive change)
2. Good contribution (mainly temporary benefit, but some permanent changes)
3. Very small positive contribution (small temporary benefit)
4. Partly positive, partly negative (i.e., mixed with the overall contribution being almost zero)
5. Negatively contribute (I got into problem as a result)

Annex: B Check list of interviews for key informants (KIs), Focus Group discussion (FGD)

1. Are you originally from this kebele?
2. How did you perceive Conservation agriculture?
3. Did you practice Conservation agriculture? If so, would you please mention the type of CA you implement?
4. Would you please define what conservation agriculture is in your understanding?
5. How do you see or compare your land production and productivity with or without CA?

6. What are the main roles of CA?
7. What are major challenges of CA you come across?
8. How see the livelihood difference of adopters and non-adopters of CA?
9. Who copes more with the effect climate change?
10. Why non-adopters do not adopt CA?
11. Is there cultural practice hindered CA in the area?