# PERFORMANCE AND CONTRIBUTION OF CONSERVATION AGRICULTURE TOWARDS CLIMATE CHANGE ADAPTATION: IN THE CASE OF GIMBI PILOT PROJECT, ETHIOPIA

M.Sc. THESIS

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER SCIENCE IN CLIMATE SMART AGRICULTURAL LANDSCAPE ASSESSMENT,

JUNE, 2018

## APPROVAL SHEET I

This is to certify that the thesis entitled ***'performance and contribution of conservation agriculture towards climate change adaptation: the case of Gimbi pilot project, Ethiopia.'*** is submitted *in partial fulfillment of the requirements for the degree of Master of Science in* ***Climate Smart Agricultural Landscape Assessment,*** the Graduate Program of the School of Forestry, and has been carried out by ***Yeshiwork Kifle, ID. No. MSc/CSA/R/0013/09,*** under my supervision and no part of the thesis has been submitted for any other degree or diploma. The assistance and help received during the courses of this investigation have been duly acknowledged. Therefore, I recommend that it to be accepted as fulfilling the thesis requirement.

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| Name of the Major advisor | Signature | Date |
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| Name of co-advisor | Signature | Date |

## APPROVAL SHEET II

We, the undersigned, members of the Board of examiners of the final open defense by ***Yeshiwork Kifle*** have read and evaluated her thesis entitled ***'Performance and Contribution of Conservation Agriculture towards Climate Change Adaptation: the case of Gimbi Conservation Agriculture Project, 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 Agricultural Landscape Assessment***.

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| Name of External examiner | Signature | Date |

Final approval and acceptance of the thesis is contingent upon the submission of the final copy of the thesis to the School of Graduate Studies (SGS) through the School Graduate Committee (SGC) of the candidate's school.

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## LIST OF ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| 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 |
| EIAR | Ethiopian Institute of Agricultural Research |
| FAO | Food and Agriculture Organization of the United Nations |
| FAPDA | Food and Agriculture Policy Decision Analysis |
| FGD | Focused Group Discussion |
| GTP | Growth and Transformation Plan |
| ICRAF | International Council for Research in Agroforestry |
| ICRISAT | International Crops Research Institute for the Semi-Arid Tropics |
| IITA | International Institute for Tropical Agriculture |
| IPCC | Intergovernmental Panel on Climate Change |
| KI | Key Informant |
| NEPAD | New Partnership for Africa’s Development |
| SIMILESA | Sustainable Intensification of Maize-Legume Cropping System for Food Security in Eastern and Southern Africa |

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## ABSTRACT

*In recent years, Conservation Agriculture is promoted as better adaptation mechanism in the face of changing climatic conditions. In Ethiopia it has been piloted in various parts of the country as fast-track response. However, the adoption status and contribution of the program is not well studied and documented. The current study was therefore conducted in Gimbi district on CA pilot project to fill this gap. The research followed mixed approach of collecting both qualitative and quantitative data. A total of 154 representative sample households were randomly selected for the quantitative survey. Moreover, focus group and key informants were used to clarify any ambiguities encountered during survey data collection. The data analysis employed both descriptive and inferential statistics. The findings of the study revealed that minimum tillage, crop residue and crop rotation were the most common CA practices used to prevail through changing climatic conditions. However, there are many challenges to implementing CA in the study area. Among the challenges were perceptions of non adopter farmers as tillage is necessary for high crop production regardless of tillage intensity, 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 with respect to the policy environment and extension services. As a solution, several CA technologies have been promoted to improve soil fertility, increase soil moisture content, increase productivity and climate change adaptation. In fact, 100 % of CA farmers indicated that they would continue to practice CA after the end of the project period. Additionally, the adoption of CA technology improves farmer's profit and eventually contributes towards reducing poverty and keeping environment clean. Finally, it is very important to giving serious attention to design policies and strategies that address problems associated with the adoption of CA based CA principles, the strategies should consider improved and disease resistance varieties of seed.*

**Key Words:** Conservation Agriculture, Climate change adaptation, Adopter, Non-adopter, Gimbi

**CHAPTER ONE**

## 1. NTRODUCTION

### 1.1. Background

Climate change has become one of the most global challenges that human being has faced in this century. The changes of climate components are caused by increases in greenhouse gases in the earth's atmosphere mainly due to anthropogenic activities (Cook *et al*., 2013; Cook *et al*., 2016). Although industry and transportation sectors are the major contributors of greenhouse gasses emission, agricultural sector is also responsible for approximately 10-17% of global anthropogenic greenhouse gases (GHG) emission through direct agricultural actives (Smith *et al*., 2007; Todd *et al*., 2011). However, when the indirect contribution via land use change and other activities are included agriculture shares about 32 % percent of greenhouse gasses emission (Greenpeace, 2008) primarily by emitting carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$) (Johnson *et al*., 2007).

In developing countries climate change has got a big influence on food security and water availability due to high level of poverty, low adaptation ability and increased population who directly or indirectly depends on agriculture (Ringler, *et al*., 2010). Thus, it leads to pressure on natural resources such as land degradation and reduction of yield in agricultural products (Ibid). Climate change and agriculture affect each other. Agricultural activities aggravate climate change via emission of greenhouse gasses while climate change negatively affects agricultural production and productivity through affecting climate variables. Particularly, inputs increments such as synthetic fertilizer and conversion of forestland, woodlands and wetlands into agricultural land to fulfill demands of rapid growing world population aggravate the negative interaction between climate change and agriculture. Thus, integration of greenhouse gasses mitigation mechanisms in agricultural activities is crucial to reconciling agricultural trade-off with climate change.

Ongoing soil and water degradation and the loss of biodiversity and ecosystem services in agricultural landscapes, constitute big challenges for future food systems (Rockström *et al*. 2009b; Balmford *et al*. 2005). To meet the world's future food security needs, conservation agriculture should expand and ecosystem services must be restored (Foley *et al.* 2011). From the 1950s, global fertilizer use has increased by 500%, and pesticide use has increased with about 850% (McKenzie and Williams 2015). Due to the high environmental costs of the inputs and high economic costs for the farmers, there is a need to find solutions for agricultural intensification that are also input-sensitive. Proposed means of achieving such improvements specifically for Sub- Saharan Africa  includes use of a 'climate-smart agriculture' approach, which emphasizes  on the use of farming techniques that (1) increase yields, (2) reduce vulnerability to climate change, and (3) reduce greenhouse gas emissions (FAO 2013). CSA includes proven practical techniques such as mulching, intercropping, conservation agriculture, crop rotation, integrated crop-livestock management, agroforestry, improved grazing and improved water management.

Conservation agriculture (CA) which is one component of climate-smart agriculture emerged as an alternative to CA as a result of losses in soil productivity due to soil degradation (FAO, 2001). CA as a climate change adaptation strategy improved soil quality and nutrient cycling. CA, in theory, has the potential to be part of a CSA strategy to agricultural policy making, however, its suitability should be assessed on a case by case basis as local agro-ecological and institutional environment play a role in determining its adoption and impacts. CA is based on the integrated management of soil, water and biological resources, and external inputs. It attempts to achieve 'resource-efficient' crop production by utilizing three farming principles: (1) minimum soil disturbance, (2) organic soil cover (Crop residual retention) and (3) diversified crop rotations (FAO, 2011; Hobbs, 2007). In focusing on three specific farming practices, the CA concept is more limited in scope than CSA, which is defined less by specific practices and more by a set of outcomes (e.g. food security, adaptation and mitigation).

Techniques in CA include zero-tillage, mulching, mixed cropping, crop rotation, and Integrated Pest Management (IPM) using botanicals rather than chemical pesticides. CA is cost effective in terms of labour, time and also requires minimum inputs unlike other types of agricultural production activities (FAO, 2008). In many parts of the world, CA practices have been widely adopted by farmers (ICRAF and ACT, 2008). Moreover, for the last decade many African countries have been exposed to no-tillage systems and CA (FAO, 2008).

In Ethiopia, soil conservation practices such as reduced tillage have long been undertaken by farmers; however, the promotion of conservation agriculture technology began in earnest in 1998 through the joint promotion and demonstration of the technology on the plots of 77 farmers by ( Sasakawa Global,2000), and regional agricultural development bureaus. Despite its promotion over the last fifteen years, adoption of CA in the country is relatively limited.

For Ethiopia, a country that has a vision of building a climate-resilient economy and having high dependency on agriculture, identifying such a combination of climate smart practices that deliver the highest payoff is valuable to help government and development agencies to design effective extension policies. According to FAO (2016) study on the performance of CA as an approach to sustainable crop intensification and how it can contribute to enhancing productivity, improving food security, reduce land and environmental degradation, enhance the flow of ecosystem services, and respond to climate change.

Gimbi district is situated in the west of Ethiopia it was the location of the project assessed in this study. In the study area the precipitation is higher than the average of Ethiopia; these areas hold some of the lushest and most productive areas in the country. Agriculture in the area is almost completely by rain-fed and there are periodic problems of drought and lack of water, precipitation shortage is still not as big of a problem in the study area and maintains the situation for the future conservation agriculture project is implemented. Contrary to this, the study area has experienced challenges of lack of land, degrading soil fertility, market access, and lack of quality seeds, tools and other inputs. Thus, the researcher motivated to evaluate the performance of conservation agriculture in Gimbi area.

## 1.2. Statement of the problem

The Government of the Federal Democratic Republic of Ethiopia has initiated the Climate-Resilient Green Economy (CRGE) initiative to protect the country from the adverse effects of climate change. In line with that conservation agriculture is increasingly being promoted as an alternative to address soil degradation resulting from poor agricultural practices. CA can adapt, to some extent, the climatic and socioeconomic challenges faced by farmers. The success of any technology depends on its dissemination among the potential users which ultimately is measured by the level of adoption of that technology. However, to fully exploit the potential of promoting the scaling up of CA the existing knowledge gaps have to be address. In Gimbi, despite all the known benefits of conservation agriculture scaling up of the technology among smallholder farmers has remained low and there is little empirical studies on factors that influence farmers to adopt CA. The Gimbi conservation agriculture pilot project However, the adoption status, adoption and contribution CA towards climate change adaptation of the program is not well studied. This study has an intention to assess the practice conservation agriculture towards climate change adaptation in Gimbi project.

## 1.3. Objective of the study

### 1.3.1. General objective

The general objectives of the study to examine the performance of conservation agriculture and its contribution towards climate change adaptation.

### 1.3.2. Specific objectives

- To examine the performance of conservation agriculture implemented at Gimbi pilot project.
- To evaluate the challenges that affect adoption of conservation agricultural practices.
- To assess contribution of conservation agriculture towards climate change adaptation at Gimbi pilot project

## 1.4. Research Questions

The research questions were:

i. What are the extent of use and the performance of CA in the study area?

ii. What are the most important socio-economic and institutional factors that affect farmers' decision to adopt CA?

iii. If CA techniques have been adopted by farmers did they increase their agricultural productivity?

iv. What are the challenges that affect adoption of conservation agriculture?

v. What are the contributions of conservation agriculture towards climate change adaptation?

**1.5. Significance of the Study**

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. Conservation agriculture should also lead to improvements in soil fertility in intensive cropping systems (Hobbs, 2007). A decline in soil disturbance and increase in crop residue retention will generally favor the accumulation of soil organic matter. The rate of such changes is probably dependent on the amounts of organic matter addition from crop residues. In Ethiopia, crop residues are often removed for use as fuel or animal fodder after harvesting the maize crop.

There is unreliable evidence to suggest that on-farm retention of residue is changing rapidly due to the impact of rising labour costs and reduced numbers of animals. The implications of the low levels of maize residues and variable levels for other crops on soil organic matter accumulation, nutrient balance and soil fertility under CA in Ethiopia are not understood but are clearly critical research questions. Economic profitability of CA in the smallholder farmer context is a crucial factor. Farmers (CA adopters) and other stakeholders who are new or are at the initial stages of converting to CA require tangible evidence on the benefits and impacts of CA. It is necessary to know whether CA significantly increases productivity and food security for their families or not.

It is also a crucial question to the CA adapters whether CA helps them save on production costs and generate income or not. For finding out the answers of those questions it is necessary to conduct an in depth analysis of the socioeconomic impacts of CA. This present study will provide an analysis of the performance and its contribution of CA towards climate change adaptation in Gimbi district. Moreover this study will serve as a base for further study similar issues.

# CHAPTER TWO

# 2. LITERATURE REVIEW

## 2.1. Definition, Concepts and principles of Conservation agriculture

### 2.1.1. Definition of conservation agriculture

Conservation agriculture (CA) is a farming approach that fosters natural ecological processes to increase agricultural yields and sustainability by minimizing soil disturbance, maintaining permanent soil cover, and diversifying crop rotations. CA has already been demonstrated to benefit large-scale and small-scale farmers in diverse contexts by increasing soil fertility, reducing input costs, saving labor and fuel, conserving water, preventing erosion, and increasing farm profitability.

CA is any soil management system that leaves the soil surface less exposed to erosion and conserve soil moisture, based on three agronomic principles; minimal soil disturbance, permanent soil cover and crop rotations (FAO, 2001). The first and second principles of improving soil fertility, organic matter content and rain water infiltration especially in the 0 to 20 cm top layer help in increasing crop production while crop rotation reduces the necessity of pesticides and herbicides in the long run (Derpsch, 2005). According to Hobbs (2006), Hobbs *et al*. (2006) and FAO (2001) CA is a technology that conserves, improves and efficiently utilizes resources through integrated management of available resources combined with external inputs. The technology is variously known as conservation tillage, no tillage, and zero-tillage; direct seeding/planting and crop residue mulching (Nkala *et al.*, 2011). The impacts of CA have been markedly positive both in agricultural, environmental, economic and social terms it is also often stated to be labour saving and presented as a potential solution to farm power shortages (FAO, 2011).

### 2.1.2. The Conceptual Framework

The conceptual framework is the narrative outline of the study which shows the relationship between variables. The conceptual framework of this study is grounded by the assumption that the decision of farmers to adopt CA is influenced by socio-economic factors and institutional factors. The socio-economic factors are age, education, farm size, household size, household income, and farmer's perception and institutional factors are extension services, credit, and infrastructure. Therefore if a farmer adopt CA it is expected that the result will be an increase of agricultural productivity, increase of food security, increase household income and increase standard living of people.

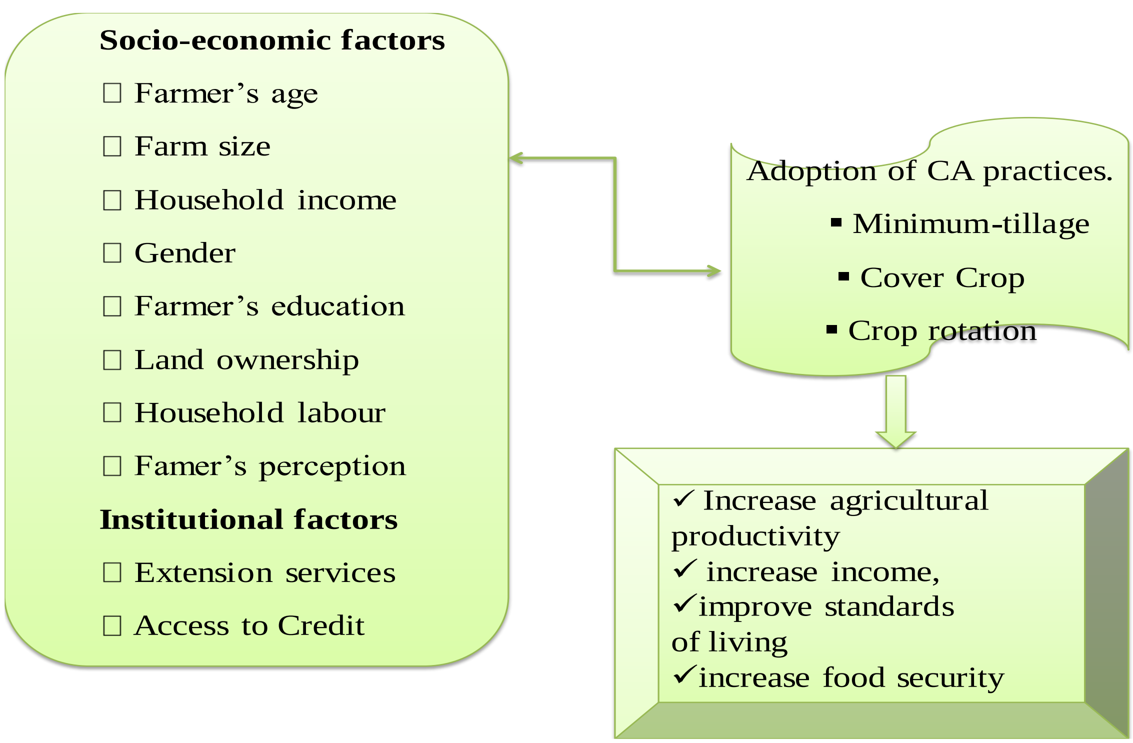



**Figure 1: Factors influencing the adoption of CA**

### 2.1.3. Principles of conservation agriculture

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 perception 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 with respect to the policy environment and extension services.

**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 tillage limits (FAO, 2001; Berger *et al.*, 2008). Strip tillage is allowed if the disturbed area is less than the set limits, land preparation for seeding or planting under no-tillage involves slashing or rolling the weeds, previous crop residues or cover crops, or spraying herbicides for weed control, and seeding directly through the mulch (FAO, 2011).

**Permanent soil cover**

Permanent soil covers 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, also it increases the soil fertility and the organic matter content of the soil, and on top of that it increases soil moisture by allowing more water to sink into the ground and 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 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 soak into the soil, and reduce the amount that runs off (FAO, 2001; 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's from trees and shrubs, to keep soil covered the use of 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).

**Diversified crop rotations**

The rotation of crops 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).

## 2.2. History, Development and relevance of CA

According to Friedrich et al. (2012), tillage was questioned for the first time in the 1930s, particularly in fragile ecosystems, when the dust bowls devastated extensive areas of the mid-west in the United States. Concepts for reducing tillage and keeping soils covered came up and the term conservation tillage was introduced to reveal such practices aimed at the protection of the soil. In the 1940s seeding machinery developments allowed to seed directly without any soil tillage. Concomitantly, Edward Faulkner with the “Ploughman’s Folly” (Friedrich et al., 2012, 3; Faulkner, 1945) and Masanobu Fukuoka in his book “One Straw Revolution” (Friedrich et al., 2012, 3 Fukuoka, 1975) elaborated theoretical concepts similar to today’s CA principles. But it was not until the 1960s that no-tillage entered into farming practices in the USA.

No-tillage farming reached Brazil in the early 1970s, where scientists together with farmers transformed the technology into the system which today is called CA. Alongside, no-tillage and mulching were also tested in the 1970s in West Africa (Greenland, 1975; Lal, 1977, 1976). Yet it took about 20 years for CA to reach significant adoption in South America and other places of the world.

During the 1990s this development progressively attracted other parts of the globe, including development organizations and international research like FAO, Centre de Cooperátion Internacionale en Recerche Agronomique pour le Développement (CIRAD) and a few centers Consultative Group on International Agricultural Research (CGIAR) (Friedrich et al., 2012).

Study tours for farmers and policy makers were created in Brazil; and regional workshops, research and development projects were organized in various parts of the world resulting in increased levels of awareness and adoption in several African countries including Zambia, Tanzania and Kenya, and in Asia predominantly in Kazakhstan and China (Friedrich et al., 2012).

After the end of the millennium, conservation tillage and no-tillage improvement practices within an integrated farming concept – such as CA - also generated increased adoption in industrialized countries such as Canada, Australia, Spain and Finland (Friedrich, et al., 2012).

Nowadays CA crop production systems have received increased interest around the world. There is only a limited amount of countries where CA is not practiced by farmers, and where there are no local research results available. In 2011, there was an estimate of a total of 125 million hectares adopting CA around the world (FAO, 2011c).

CA is practiced by farmers from the arctic circle, such as Finland; over the tropics particularly in Kenya and Uganda; to about 50º latitude South in the Malvinas/Falkland Islands; in several countries of the world from sea level to 3,000 m altitude like Bolivia and Colombia; in extremely dry conditions from 250mm /year – like Morocco and Western Australia – to heavy rainfall areas with 2,000 mm/year (Brazil) or 3,000 mm a year (Chile) (Friedrich, 2012).

No-tillage is practiced on all farm sizes; from less than half a hectare in countries like China and Zambia; to thousands of hectares such as those in Argentina, Brazil and Kazakhstan. It is practiced on soils that vary from 90% of sand like in Australia; to 80% clay common in Oxisols and Alfisols of Brazil (Friedrich, 2012).

Even though soils with high clay content are extremely sticky this has not been an obstacle to no-till adoption when appropriate equipment is available. Soils which under tillage farming are eagerly prone to crusting and surface sealing do not present this problem under CA due to the fact that the mulch cover avoids crusting formations (Friedrich, 2012).

CA has equally allowed expansion of agriculture to land areas viewed as marginal in terms of fertility and rainfall common in land extensions in Australia and Argentina. All crops can grow adequately in CA; and there is still no evidence found of a crop that has not successfully grown and produced under this system, including tuber and root crops ((Friedrich, 2012; Derpsch and Friedrich, 2009).

However, the main barriers of CA practices' adoption remain: the know-how (or the knowledge on how to do it properly); people's mindset (tradition, habit, culture, prejudice); inadequate policies like commodity based subsidies in the EU and the US and direct farm payments (in EU), lack of availability of appropriate machines and equipment in many countries of the world; unavailability of suitable herbicides to assist on weed and vegetation management – especially for large scale production farms in developing countries (Friedrich, 2012;.FAO, 2008; Friedrich and Kassam, 2009).

Throughout these years and all these mentioned countries above, it was clear that the method used in Conservation Agriculture has always been based on the direct planting, mulch the soil to prevent soil degradation and soil fertility. All these features are similar to those used in the present study.

### 2.2.1. Global Area and Regional Distribution in CA

There are no officially reported global data of CA adoption. All information is collected from local farmers and interest groups. The data is then assembled and published by FAO (Friedrich, 2012; FAO, 2011c). For the data collection, CA definition is quantified as per the following:

I. Minimum Soil Disturbance which refers to low disturbance, direct seeding and no-tillage soils. The area that has been disrupted must not exceed 15 cm wide or the equivalent to 25% of the cropped area (whichever is lower). There should be no periodic tillage that disrupts a greater area than the above-mentioned limits. Strip tillage is acceptable if the disrupted area is less than the set limits.

II. Organic soil cover with three distinguished categories: 30-60%, >60-90% and >90% ground covers, measured right after direct seeding operations. Areas with less than 30% cover are not considered as CAs.

III. Crop rotations/associations that should involve not less than 3 different crops. Despite the fact that repetitive wheat or maize cropping is not a prohibited factor for the purpose of data collection, rotation/association is recorded where practiced.

**Table 1: Area under Conservation Agriculture by continent**

| # | Continent | Area(ha) | Percent of total |
|---|---|---|---|
| 1 | South America | 55,464,100 | 45 |
| 2 | North America | 39,981,000 | 32 |
| 3 | Australia &New Zealand | 17,162,000 | 14 |
| 4 | Asia | 4,723,000 | 4 |
| 5 | Russia &Ukraine | 5,100,000 | 3 |
| 6 | Europe | 1,351,900 | 1 |
| 7 | Africa | 1,012,840 | 1 |
| **World total** | | **124,794,840** | **100** |

*Source: FAO, 2011c*

As shown in Table 1: 45% of the total global area under Conservation Agriculture is in South America, 32% in the United States of America and Canada, 14% in Australia and New Zealand and 9% in the rest of the world including Europe, Asia and Africa. The latter are the developing continents in terms of Conservation Agriculture adoption" (Friedrich, et al., 2012, 5). Despite good and long lasting results in Africa and Asia showing positive results for no-tillage systems, CA has experienced small rates of adoption (Ibid).

Areas under CA systems have been growing exponentially, largely as a result of initiatives developed by farmers and their organizations and due to CA systems benefits. These benefits include yield, land use sustainability, incomes, ease of farming and ecosystem services and appropriateness of cropping practices (Friedrich, et al., 2012).

### 2.2.2. Conservation Agriculture Adoption in Sub-Saharan Africa

Innovative partaking approaches are being used to develop supply-chains for creating CA equipment supporting small holders in the Sub-Saharan Africa. "Similarly, participatory learning approaches such as those based on the principles of Farmer Field Schools (FFS) are being encouraged to strengthen farmers' understanding of the principles underlying CA and how these can be adapted to local situations" (Friedrich, et al., 2012,9).

CA is spreading to the Sub-Saharan Africa region, predominantly in the eastern and southern part of Africa as shown in Table 2.5. Building on scientific and indigenous knowledge, Latin America equipment design, and more recently with the collaboration from Bangladesh, China and Australia, there are now at least 14 African countries using conservation agriculture: Sudan, Kenya, Tanzania, Malawi, Zambia, Zimbabwe, Mozambique, Madagascar, South Africa, Lesotho, Swaziland, Ghana, Uganda, and Burkina Faso. Additionally, CA has been integrated by NEPAD (New Partnership for Africa's Development) into the regional agricultural policies (Friedrich, *et al.*, 2012).

In the specific circumstances surrounding Africa where farmers have limited resources, CA systems are relevant for focusing at the challenges of climate change, environmental degradation, high energy costs, and labor insufficiencies. Even though the area under CA is still relatively small, there is a steady growing movement that comprises more than 400,000 small-scale farmers for a total area of approximately 1M ha (Friedrich, et al., 2012).

**Table 2: Conservation Agriculture adoption in Sub-Saharan Africa**

| # | Country | Conservation area(ha) |
|---|---|---|
| 1 | Ghana | 30,000 |
| 2 | Kenya | 33,000 |
| 3 | Lesotho | 2,000 |
| 4 | Malawi | 16,000 |
| 5 | Madagascar | 6,000 |
| 6 | Mozambique | 152,000 |
| 7 | Namibia | 340 |
| 8 | South Africa | 368,000 |
| 9 | Sudan | 10,000 |
| 10 | Tanzania | 25,000 |
| 11 | Zambia | 200,000 |
| 12 | Zimbabwe | 139,300 |
| **Total** | | **981,640** |

*Source: FAO, 2011c*

CA is equally expected to increase food production in the In Sub-Saharan African region while reducing environmental negative effects and energy expenses. This will contribute to the development of locally-adapted technologies congruent with CA principles (Friedrich, et al., 2012).

According to Milder, *et al.* (2011) in 1995, the Zambian Conservation Farming Unit (CFU) was established in an effort to address the acute challenges of small farmers in Zambia, with the hypothesis that Conservation Agriculture (CA) could help relieve problems of environmental degradation and food insecurity. The initial acceptance was slow. Farmers were hesitant towards the new practices, and there were no immediate availability of indispensable tools and machinery. The new approach often required initial labor investment, and there were not always immediate positive results. But as gradually farmers acquired higher yields and profits, especially during dry season, word spread and adherence to this system increased. “The number of small farmers practicing CA in Zambia rose from 20,000 in 2001 to 180,000 in 2009” (Milder, *et al.* , 2011,2; Giller et al., 2009). By the end of 2011, CFU goal was to increase adoption of CA to 250,000 families, the equivalent to 30% of Zambia’s small farmers. “Most of these farmers have boosted grain yields, while in many cases reducing farm labor demands and decreasing susceptibility to drought” (Milder, *et al.* , 2011,2; Giller et al., 2009).

Considering the Zimbabwe Case Study Marongwe et al. (2012, Xi), report that agricultural productivity in Zimbabwe, like in many other countries in SSA has been declining over the years despite the numerous advancements made in agricultural technology development. Yield levels usually averaging below 1t per ha have resulted in persistent cereal deficits despite the large area put under production each year. Declining soil fertility, erratic precipitation patterns, high input costs and unstable market conditions have all affected the profitability and therefore the sustainability of the small holder farming sector, which provides livelihoods for the majority of the rural population. Thus, conservation agriculture is increasingly being seen as a farming system that can reduce the negative impacts of some of the factors that are limiting agricultural productivity. Its component technologies of minimum soil disturbance, maintenance of organic ground cover and the use of suitable crop rotations and interactions have shown the potential to mitigate some of the production constraints experienced in the country's agricultural production. Sixty percent of Zimbabwe is based in Natural Agro Ecological Regions.

According to survey reports from Zimbabwe Ministry of Agriculture, the total number of farmers practicing Conservation Agriculture options during the 2010/2012 agriculture seasons, has increased tremendously, with a significant proportion implementing Conservation Agriculture without any input support showing increasing appreciation of CA benefits by farmers in the country. Although the total number 372.000 constitutes about one third of the communal farmers who grow most of the staple food, the area (141.334 ha) in (2001) only constituted about 5 percent of area planted to maize during the year. "However, farmers still face challenges in maintaining an adequate ground cover due to the communal grazing systems that are observed in most areas and high labor demands of hand-based CA systems for land preparation and weed management"(Marongwe, et al., 2012,16).

In accordance with the African Leaders State Africa Report (2011) with regards to food security Malawi is a globally recognized success. The Malawian Government has rendered an overruling priority to agriculture development and food security. It has have heavily invested in the agriculture sector, especially in the Farm Input Subsidy Programme (FISP). Despite the fact that Malawi was experiencing prolonged dry seasons in some regions threatening food security it managed to harvest 3.2M metric tons of maize in 2011 with a surplus of 800,000 metric tons above the country's annual food requirements.

With regard to Mozambique, the knowledge about Conservation Agriculture is limited as compared to other countries. This is one reason why the researcher wants to do this study. So at the end of the research it will be possible to make a comparative study with the facts and ideas presented in order to draw conclusions regarding Conservation Agriculture. At the end of the research, the researcher wants to find out if it actually yielding using the methods of Conservation Agriculture, and if it is possible to reduce poverty in Mozambique.

#### 2.2.3. Conservation Agriculture and Organizations that support their policies

Cooperative for Assistance and Relief Everywhere (CARE) has supported projects of Conservation Agriculture-based agricultural development in the African continent, including Ghana, Sierra Leone, Mali, Liberia, Tanzania, Angola, Zambia, Zimbabwe, Mozambique and Lesotho with the goal of increasing crop harvests and farmers' incomes, reversing the land degradation process and improving the lives of more vulnerable families, especially women. Furthermore, CARE has launched new important initiatives focused on adaptation to climate change in order to assist rural communities face the challenges to food security, drinking water availability, human health and decreasing natural resources triggered by climate changes (Milder, *et al.*, 2011).

### 2.3. Climate change adaptation

According to IPCC (2007), adaptation is defined as the "initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects". For human systems, adaptation has the purpose of moderating, avoiding or preventing negative impact of these changes or exploiting the advantages of opportunities created by these changes (FAO, 2013). Different types of adaptation exist. It is for example the preventive and reactive adaptation, public and private adaptation, autonomous and planned adaptation (IPCC, 2007; FAO, 2013). Adaptation to climate change is not new to humans. They have developed the ability of responding to natural or human induced effects of climate change several times in the past (IFAD, 2011). It is for example migrations, extending agriculture to unexploited land, using synthetic fertilizers and pesticides, development of new crops and animal breeds adapted to change, etc. However some of these measures developed have enhanced the effect of climate change. Improved methods of adaptation are required in order to adjust to the changing climate.

### 2.4. 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 a 2.6% growth rate according to the Ethiopian Central Statistical Authority (2008), a 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 on long term agricultural development, and implemented, for instance, a widespread social protection programme (the Productive Safety Net Programme or PSNP) in 2005. A positive effect of these efforts is that the country recently reached the Millennium Development Goal 1 on halving the proportion who suffers from hunger. Unfortunately, about 32% of the population are still undernourished, and 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 and Schmidt 2012).

## 2.5. 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 on CSA and CA practices (2016), which provides some of the most comprehensive and updated information on the subject. In Ethiopia, soil conservation practices such as reduced tillage; have throughout history variably been undertaken by farmers in different places as a traditional method.

However, the active promotion of CA technology is quite new and started in 1998 by something called the Sasakawa Global, 2000 initiative. 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 is 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, Amhara and Tigray. However, in general, adoption rates in Ethiopia are not well enough documented. In terms of adopting different CA components, Wondwossen *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 labour productivity (yield per unit of labour), implying that most labour is saved from full adoption of all the CA components.

The promotion and adoption of CA technology in Ethiopia is constrained by various factors. FAO's study (2016) found that the guidelines from the authorities are not on a sufficiently 52 detailed level, and manuals and action plans and are not sufficiently mainstreamed into existing programmers' and projects. In addition, there are challenges of weak integration into existing extension services, prevalence of open grazing, shortage of livestock feed, and lack of knowledge on appropriate cropping systems, crop rotations and intercropping combinations.

### 2.6. Challenges to conservation agriculture promotion in Ethiopia

***Inadequate integration of conservation agriculture into the Agricultural Extension Service:*** 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. In particular, 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.

***Lack of availability of required inputs and equipment:*** It has frequently been reported that inputs such as non-selective glyph sate -based herbicides are difficult to access and those that are available are not effective, thus making it difficult for farmers to adopt conservation agriculture owing to weed problems. The same applies to other inputs required for practicing conservation agriculture such as seeds for rotation crops as well as conservation agriculture implements such as rippers and direct seeders, which are not available at times or, when available, are of poor quality.

***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.

### 2.7. 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:

#### 2.7.1. Socio-economic factors

**Farmer's age**

Age is an important factor that influences the probability of adoption of new technologies since it is said to be a primary latent characteristic in adoption decisions (Akudugu *et al*., 2012). 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 counterpart (Amir, 2006). On top of that, older farmers tend to be risk averters 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 *et al*., 2009

**Farm size**

Farm size influence farmer's participation in conservation farming thus inadequate farm size can affect farmer's decision of adopting CA (Feder *et al*., 1985). Farmers with large arable land have the opportunity to spare some sections to try out new practices at less risk. Large land size also implies that farmers can diversify into other crops and reduce the inherent risk in agricultural production (Perseverance *et al*., 2012).

A study by GabreMadhin and Haggblade (2001) found that large commercial farmers adopted new high yielding maize varieties more rapidly than smallholders in Kenya. Large farm size also gives a farmer the capacity to use land intensive conservation practices (elements) such as improved fallow and crop rotation (Thangata *et al*., 2002).

**Household size**

Household size has been linked to the availability of own/family farm labour in adoption studies (Amsalu and De Jan, 2007). The argument is that larger households have an importance in the determinant of the availability labour required during the introduction of new technologies (Woziniak, 1984). It is expected that a larger household size will influence the decision of acceptance because of the availability of labour required during the adoption process; hence household size increases the chance of farmers to adopt CA (Woziniak, 1984). Labour constrains can affect the decision of farmers to adopt conservation farming (Feder *et al*., 1985).

**Education**

Education is a major factor that can influence the adoption of any innovation. Through education Norman (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 the readiness 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, the more complex the technology to be utilized the more likely it is the education will play the major role (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 their perception is negative or indifferent (Ayuya *et al*., 2011).

### Household income

Household income plays a role of financing the uptake of new innovation. Serman and Filson (1999) argued 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 and De Jan, 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, 2003). 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 (CIMMTY, 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 meetings (Morris, 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 *et al*., 2009).

**Land tenure system**

According to Adjei *et al*. (2003) the settlement of farmers at one place has an important implication on access or control of resources and long term investment on the farm, a migrant with short stay on the land will be unwilling to invest capital and labour in practices of which the effects can only be realized after the period of time that is farmers are not likely to invest to a land of which long term access is not secured. The hired land especially when it is rented for 2-3 years is the constraining factor for adoption of CA because the landlords might need the land back when the soil fertility has distinctly improved and crop production has increased (Adjei *et al*., 2003).

### 2.7.2. 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 *et al*., 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 agrochemicals; the high cost of farming inputs has a significant impact on cash demand of farmers during the farming season (Adjei *et al*., 2003).

**Extension Services**

Extension is regarded as a process of integrating indigenous and derived knowledge, attitudes and skills determined assistance available to overcome particular obstacle (FAO, 2004). 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 increasing production that ultimately improves their socio-economic status (Mlonzi, 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, 1994).

### 2.8. Performance of CA Practices in Oromia Region.

Performance assessment of CA practice among the 111 farmers who hosted CA demonstration in 2015, 46 farms was selected for yield assessment. Demonstration plots were monitored frequently by the DFN field officer, local development agents and CIMMYT staff. Monitoring was useful to check whether recommended field practices were followed during each of the critical stages. The major technical issue was that the yield was estimated based on only three maize cobs taken from a 4m*4m plant cut. The weight of all maize in the 4m*4m harvest area would have been weighed. It seems that there was a misunderstanding on the number of cobs to be shelled for moisture content and the total number of cobs to be weighed in the harvest area. The major difference between farmers' field and CA plots was on final plant density. CA plots had a density of 42,935 plants/ha whereas farmers' field had an average of 39,755 plants/ha. However, the target density in the CA plots was 62,500 plants/ha (80 cm inter-row 20 cm inter-plant spacing). It is probably possible to further increase the potential yield by achieving over 50,000 plants/ha.

### 2.9. Definition of Important Terms

For clarity of understanding, certain terms frequently used throughout the study are defined and interpreted as bellows:

**Age**: Age of an individual farmer as defined as the period of time in years from his birth to the time of interview.

**Adoption**: According to Rogers (1955) "Adoption is a decision to make full use of an innovation as the best course of action available". OR

Feder *et al,* (1985) defined adoption as "a mental process an individual passes from first hearing about an innovation to final utilization.

**Annual income**: Annual income referred to the total earnings of respondent and other members of his/her family from agriculture and non-agricultural (service, business etc.) sectors during a year.

**Family size**: Family size referred the actual number of members in the family of a respondent including him/herself, spouse, children and other dependents, who lives and eat together in a family unit.

**Farm size**: The term used to refer the cultivated area either owned by a farmer lease or other means. Farm size was measured in terms of hectares.

**Level of education**: Level of education referred to the development of desirable change in knowledge, skill, attitude and ability in an individual through reading, writing, working, observing and other related activities. It was performed by the formal education of a farmer by taking into account of year he/she spent in formal educational institutions.

**Variable**: A general indication in statistical research characteristic that occurs in a number of individuals, objects, groups etc. and that can take on various values, for example the age of individual.

**Respondents**: People who have answered questions by an interviewer for a social survey. They are the people from a social research worker usually gets most data required for his research.

**Extension contact**: Extension contact refers to one's access to the communication process through various extension teaching methods during one year prior to data collection.

**Farming experience**: It means the experience which one gains from farming activities directly. Farming experience of farmer was measured in years which he/she gained from involvement in farming activities.

**Climate Change** is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years because the effects of natural processes and human action.

**Conservation Agriculture** is a type of agriculture that not only promotes conservation of natural resources (soil, water and biodiversity) but that is also economically viable and promotes social equity. According to FAO, the most generic definition of CA is a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. CA is based on enhancing natural biological processes above and below the ground. Interventions such a mechanical soil tillage are reduced to an absolute minimum, and the use of external inputs such as agrochemicals and nutrients of mineral or organic origin are applied at an optimum level and in a way and quantity that does not interfere with, or disrupt, the biological processes.

**CHAPTER THREE**

# 3. MATERIALS AND METHODS

## 3.1. Description of the study area

The study was conducted in Gimbi Woreda (district) of Oromia Regional State. Geographically, it is located between $9^0$10’0’’ and $9^0$10’30’’N latitude and $35^0$42’0’’ and $35^0$55’30’’ E longitude with its capital- Gimbi town located 440km west of Addis Ababa.

Gimbi woreda has an estimated area of 1,183.44 square km; bordering in south by Haru, on the Southwest by Yubdo, in the West by Lalo Asabi, and in the North by the Benishangul-Gumuz Region, on the east by the East Wollega Zone, and on the Southeast by an exclave of the Benishangul-Gumuz Region. The woreda has a total of 32 Kebeles, of which 30 are rural. The Woreda total population and households are estimated to be 74,623 and 18,301 respectively. Of the total households, 97% are rural residents making their livelihood from agriculture (GWOoA, 2015.)

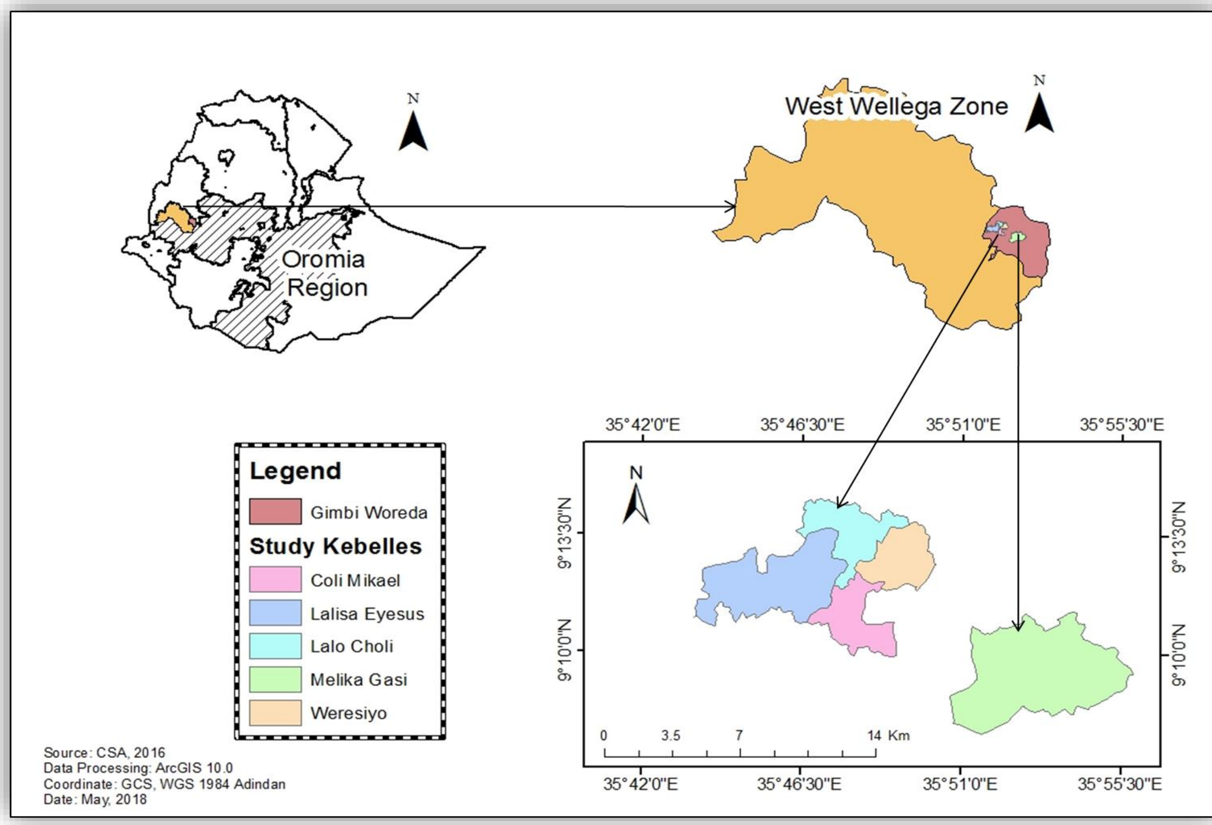



Figure 1: Study area map

### 3.1.1. Vegetation

Currently natural forest coverage of the Woreda is 15,389 ha. Woodlots, boundary planting, scattered trees on crop lands, and maize cultivation practice near to the homestead are the major practices and source of livelihood in the Woreda. The most dominant tree species found in the Woreda are *Cordia africana*, *Eucalyptus camaldulesis*, *Sapium ellipticum*, Cupressus *lusitania*, *Vernonia amygdalina*, *Erythrina abyssinica*, *Celtise africana*, *Aaccacia* spp, and coffee. The vegetation type had largely been disturbed by human activities changing it gradually from primary forest to agricultural land use depriving the area of its valuable tree species. In general, from the total land area of the Woreda; 5,607 ha of grazing land, 23,345 ha agricultural land more than 28,530 ha of coffee, and 14,100 ha were covered by annual crop.

### 3.1.2. Climate

Lowland and midland agro-ecological zones characterize the woreda's climate. The woreda minimum annual temperature $14^{o}$c and the maximum temperature reached as high as $26^{o}$c and the mean annual rain fall ranges from 800 to 2000 mm. The main rainy season in the woreda is from March to end of May and from June to end of half of September (GWOARD, 2015). From 32 Kebeles of the Woreda, 29 are classified under midland agro-ecological zones, while the remaining three are in Lowland agro-ecological zone.

### 3.1.3. Economic activities and source of income

The economy of the Woreda is dominated by traditional cash and other crops such as maize farming mixed with livestock husbandry. The major crops produced in the Woreda include, maize and sorghum, wheat, teff, millet, chickpea, pea, and from vegetables, shallot, garlic, carrot, beat root, cabbage (GWOARD, 2015). In addition to production of crops farmers in the Woreda also rear livestock. The population of livestock includes cattle, sheep, goats, chickens, equines and bee hives. Except for the very small areas under vegetables and fruits, crops all farms are grown under rain fed condition. In the area, sesame, coffee, and maize are the most important marketable commodities, and accounted for 90% of the Woreda cultivated area.

## 3.2. Study design and Method of Data collection

### 3.2.1. Study site selection

The rationale for the choice of West Wellega zone of Oromia Region, with its capital- Gimbi district for the study was made through discussion with the regional natural resource department based on previously practices of CA project for the last three years (2015-2017) and its wide range of Agro-ecological conditions, its ideal representativeness of mid and lowland areas and presence of mixed farming practices.

### 3.2.2. Sample size determination

In order to select a representative sample two-stage random sampling techniques were implemented. In the first stage, with the consultation of Woreda agricultural experts and development agents, five CA potential kebeles were purposively selected based on the level of production. In the second stage, using the list of households in the sampled kebeles, 154 Sample Households were randomly selected based on the total numbers adopter and non adopter household.

### 3.3. Methods of data collection

#### 3.3.1. Physical observations

Systematic physical observation was carried out to gather general information such as system of land size, type of CA method applied by the farmers, types of crop grown under CA and tools used in practicing CA.

#### 3.3.2. Key informant selection (KIs)

In this study, KIs were referred to 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. Their participation in pilot project of the kebeles was also considered as a criterion for selection as KI. The KIs were selected following the snowball method (Bernard, 2011). The selection of KIs was done with the help of the Kebele administrators and elderly persons asking a randomly selected three farmers from each Kebele to give names of five KIs based on the above criteria. Then the mentioned KIs were ranked and the most frequently appeared top three farmers were selected as the KIs in each Kebele. In general, 15 KIs was selected for the whole study area.

The information about CA and their existing condition, their management practices, NGOs and government initiatives in CA, challenges of CA were discussed with the key informants. The information taken from key informants was used for triangulation of households' surveyed data.

### 3.3.3. Focus group Discussion (FGD)

In this study focus group discussions (FGD) were made with the community including elders, women, and youth groups. The participants for the FGD were selected based on experience and having a better knowledge on the present and past environmental, social and economic status of the study area.  At each Kebele, two separate FGD were carried. The two focus groups discussion were (one for adopter and the other one to non-adopter), each having 10-12 members, were selected in five Kebeles. For practitioners' focus group discussion, individuals who have good experience in CA practices were purposively selected.. Focus group discussions were also employed after the individual household survey to clarify issues that were vague during the survey.

## 3.4. Household selection

### 3.4.1. Selection of Sample Households (HHs)

Stratified sampling was employed to identify farmers as practitioners of the CA based practices and non-practitioners. Households for the study were selected at two stages. First, Woreda with CA based practice was identified and selected. This was followed by the division of farmers practicing CA based farming system and farmers continuing without CA incorporation but practicing conventional practices in the Kebele. The sampling frame for adopter (participants in CA) was farmers' list from the respective Woreda Agriculture Office registered as CA participants, from Kebele administration (both practitioners and non-practitioners), through a reconnaissance field visit and key informant verification. Households were labeled as 'practitioners' and 'non-practitioners' based on their efforts in incorporating CA in their farming practices. Selection was based on the motive to select adopter (households practicing CA farms) and non-adopter households (household not engaged in CA practices) living in the same Kebele; the ‘‘non-practitioners’’ group had not adopted CA but followed conventional way of farming.

### 3.4.2. Sample Size Determination and Sampling Techniques

The study followed multi-stage stratified random sampling techniques. In the first stage, Gimbi woreda was purposively selected due to wide range of agro-ecological condition and because of the presence of CA pilot project. In the second stage, The Woreda is stratified in to two based on adoption/practice of CA and five  kebeles were selected purposively. At the final stage sample household were randomly selected following representation to population size (PPS) approach.

Sample households were selected randomly by using separate lists of practitioners and non-practitioner of CA household heads. Households were sampled randomly using standard formula (Slovin, 1960) to determine the required sample size at 93% confidence level, and level of precision = 7%;

$$n = \frac{N}{1+N(e)2} \quad \text{……………………………………………………………………….. (1)}$$

$$n = \frac{640}{1+640(0.07)2}$$

n = 154

Where  n  is the sample size,

N is the population size (total household heads size), and

e is the level of precision.

Allocation of the number of samples of farm households in each kebele was decided proportionally on the basis of the number of households in each sample kebele.

From the total 640 households, 154 households were sampled in the study area for entire survey. Since the numbers of farmers in each category can be different, specific numbers of respondents were being selected with probability proportionate to size (PPS) random sampling technique to ensure representativeness of the population.

Consequently, from the total of 154 sample respondents were being selected to provide information (adopters 100 and non-adopters 54 selected in the categories). Since the number of household heads in the two groups are non-proportional, unequal number of sample is drawn from each group, that is, 100 household heads were sampled from practitioners and 54 from non-practitioners each group and a total of 154 household heads were interviewed.

Table 1: Households sample distribution of CA practitioner and non-practitioner.

| **HHs in the kebele** | | | **Sample HH** | | |
|---|---|---|---|---|---|
| Adopter | Non-adopter | Total HH | Adopter | Non-adopter | Total |
| 311 | 329 | 640 | 100 | 54 | 154 |

### 3.4.3. Types and Source of Data

This study employed two types and sources of data .They are primary and secondary data. Primary data is original data that has been collected. It is first hand information. In this study, primary data was collected by structured questionnaire and interview. The secondary data is the data which was obtained from second hand information sources which was collected by someone other than the user. It is obtained from books, journals and articles.

### 3.5. Data Processing and Analysis

Data collected was coded, edited and entered in computer software using a programme of Statistics Package for Social Science (SPSS). The SPSS employed both descriptive and inferential statistics, where by descriptive statistics was used to find the percentage, mean and frequency to describe variability and central tendency of the variable. The inferential statistics was used for objective number two.

**CHAPTER FOUR**

# 4. RESULTS AND DISCUSSION

This section of the study deals with results and discussion. Based on data collected from 154, the findings of the study are presented as below.

## 4.1. Socio-Demographic Characteristics of Respondents

### 4.1.1. Farmer's age

The first socio demographic characteristic was farmer's age. Pertaining age the result presented as follows.

Table 2: Respondent, Farmer's age of respondents

| Age | Adopters (n=100) | | Non adaptors (n=54) | | $X^2$ | df | P-value |
|---|---|---|---|---|---|---|---|
| | n | % | n | % | | | |
| 20-35 | 24 | 24 | 8 | 15.00 | 26.519 | 3 | .000 |
| 36-45 | 56 | 56 | 10 | 19.00 | | | |
| 46-55 | 12 | 12 | 15 | 28.00 | | | |
| 56+ | 8 | 8 | 21 | 39.00 | | | |
| Total | 100 | 100.0 | 54 | 100.0 | | | |

Source: field Survey, 2018

The age of farmers was categorized into three categories for both adopters and non – adopters. The findings show that about 56 of the respondents aged 36-45 adopted CA while 19% in the same age category did not adopt CA. It was also found that 39% of respondents of non adopters were in the age category of 56+. Furthermore 9 % of the respondents were aged between 20-35 adopted CA while15 percent in the same age category did not adopt CA. This implies that farmers who adopted CA were adult found in age category of 36-45, this group is responsible in decision- making on adoption of CA and thus age of the farmer can positively influence the decision of farmers to adopt CA. These results are similar to the study of Harford (2009) who argued that with an increase in age farmers tend to reject new farming practices for less demanding cropping systems with low transactional cost associated with them. Further, the calculated chi- square test value was 26.519 at 3 degree of freedom which was greater than the statistical significant value of 0.05. Additionally, the calculated p-value was less than the usual statistical significant value of 0.05 (P<.05).This implies the result is statistically significant. Furthermore, older farmers tend to be risk adverse and may avoid innovations in an attempt to avoid risk associated with the initiative. Rukuni *et al.* (2006) argued that being older creates a conservative feeling among farmers and hence resistance to change.

### 4.1.2. Family size of the respondent household

The second socio demographic characteristic of respondents which is included in this study is household size of the respondents. The result presented as follows.

Table 3: Family size of the respondent household

| Level of house size | Adopter category | | | | $X^2$ | Df | P-value |
|---|---|---|---|---|---|---|---|
| | Adopter (n=100) | | Non-adopter (n=54) | | | | |
| | n | **%** | n | **%** | | | |
| 1-3 | 12 | 12.00 | 7 | 13.00 | 91.143 | 3 | .000 |
| 4-6 | 47 | 47.00 | 28 | 52.00 | | | |
| $7^+$ | 41 | 41.00 | 19 | 35.00 | | | |
| Total | 100 | 100.00 | 54 | 100.00 | | | |

Source: field Survey, 2018

Table 3 showed that household of respondents. The results of household size were categorized into three groups, among adopters 12% were found in a group of 1-3 members, and 47.00% were ranging in 4-6 members and the last group of 7 and above was about 41.00 %. where by the majority 52% of farmers who were non-adopters were in a group of 4-6 members, and about 13 % were in a group of 1-3 members, and only 35% were in a group of 7 and above members, while The findings show that among non adopter farmers majority were found in group of 4-6 members. The calculated chi square test value was 91.143 at 3 degree of freedom which was greater than the statistical significant value of 0.05. Additionally the calculated p value was .000 which was less than the usual statistical significance value of 0.05 .This implies the result is statistical significant. It implicates that the number of family members of the household might influence farmers' decision of adopting CA. Ayuya *et al.* (2011) made an argument that the larger households have the capacity to relax the labour constraints required during the introduction of new technologies. Therefore it is important to know the household size of the respondents in studying adoption

### 4.1.3 Educational Status of the respondents

The third demographic characteristic of respondents is level of education. The result presented as follows.

Table 4: Educational Status of Respondents

| Level of education | Adopter category | | | | $X^2$ | Df | p-value |
|---|---|---|---|---|---|---|---|
| | Adopter (n=100) | | Non-adopter (n=54) | | | | |
| | n | % | n | % | | | |
| Illiterate | 11 | 11.00 | 34 | 63.00 | 25.792 | 3 | .000 |
| Read and write | 24 | 24.00 | 16 | 30.00 | | | |
| Primary | 52 | 52.00 | 4 | 7.00 | | | |
| Secondary | 13 | 13.00 | 0 | 0.00 | | | |
| Total | 100 | 100.00 | 54 | 100.00 | | | |

Source: field Survey, 2018

A result shows that about 52% of adopters at least attained primary level education while only 4% of the non-adopter attained primary education. Neither adopters nor non-adopters of CA had attained to college or university. It implies that farmers' education may significantly influence participation in CA but with more years in schooling probability of participating decreases. The calculated chi square test value was 25.792 at 3 degree of freedom which was greater than 0.05. Furthermore, the calculated statistical significant value was .000 which is less than the usual statistical significant value of 0.05. Thus, the result is statistically significant. Same results found by Perservance *et al.* (2012) in the study of adoption and efficiency of selected conservation agriculture technologies found that educated people tend to reject agriculture activities. In general it is a positive relation between level of education and adoption. It was given by years spent in school and the adoption of CA. It was hypothesized that the educated farmers are more likely to adopt CA because they can use information relevant for adoption

### 4.1.4. Level of Household Farm size

Under this section household farm size is presented and the results are given.

Table 5: Household Farm size (ha)

| Household Farm size (ha) | Adopter category | | | | $X^2$ | df | P-value |
|---|---|---|---|---|---|---|---|
| | Adopter (n=100) | | Non-adopter (n=54) | | | | |
| | n | % | n | % | | | |
| 0.25- 0.75 | 9 | 9.00 | 36 | 66.67 | 42.325 | 2 | .000 |
| 0.76-1 | 76 | 76.00 | 11 | 20.37 | | | |
| >1 | 15 | 15.00 | 7 | 12.96 | | | |
| Total | 100 | 100.00 | 54 | 100.00 | | | |

Source: field Survey, 2018

In the study area about 76% of adopters and 20% of non adopters own 0.88ha and also those who own 0.25-0.75 are 9% for adopters and 36% for non adopters, This shows that there was differences in size of land possessed by adopters and non adopters of CA.

The calculated chi square test value was 42.325 at 2 degree of freedom which was greater than the usual statistical significant value of 0.05 .Moreover, the calculated statistical significant value was .000 which was less than the usual statistical significant value of 0.05($P<0.05$) .This implies that the result is statistically significant. Adopters of CA tend to have large size of land compared to non adopters. These results are similar with those Just *et al.* (1980) who claimed that adoption of an innovation will tend to take place earlier on larger farms than smaller farmers. Large land holding are more likely to adopt a technology than small holders (CIMMYT, 1993).

### 4.1.4. Sex of the respondents

Table 6 : Sex of the respondents

| Sex | Adopter category | | | | $X^2$ | df | P-value |
|---|---|---|---|---|---|---|---|
| | Adopter (n=100) | | Non-adopter (n=54) | | | | |
| | n | **%** | n | **%** | | | |
| Female | 9 | 9.00 | 13 | 24.00 | 75.740 | 1 | .000 |
| Male | 91 | 91.00 | 41 | 76.00 | | | |
| Total | 100 | 100.00 | 54 | 100.00 | | | |

Source: field Survey, 2018

Among the total respondents, 85% were male and 15% were female household heads. About 91% of the CA practitioners were males while 9% were females. Also, 24% of non-practitioners were females while 76 % were males. The result indicated that poor involvement of women in conservation agriculture. Moreover, the result was tested by employing t-test. The calculated chi-square test value was 75.740 at 1 degree of freedom which were greater than the statistical significant value of 0.05. Additionally, the calculated p-value was .000 which was less than the usual statistical significant value. Thus the result is statistically significant. the This may be due to female dependency on their husbands in taking farming decisions (Adeniji, 1991) and probably women are too involved in both farm and non-farm activities a situation likely to make them less available for the interview.

#### 4.1.5 Marital status of the respondents

Under this section deals with marital status of the respondents .The result obtained from the data presented as follows.

Table 7 : Level of Marital status of households

| Sex | Adopter category | | | | $X^2$ | df | P-value |
|---|---|---|---|---|---|---|---|
| | Adopter (n=100) | | Non-adopter (n=54) | | | | |
| | n | % | n | % | | | |
| Single | 7 | 7.00 | 11 | 20.00 | 403.662 | 4 | .000 |
| Married | 86 | 86.00 | 36 | 67.00 | | | |
| Separated | 1 | 1.00 | 0 | 0.00 | | | |
| Divorce | 1 | 1.00 | 2 | 4.00 | | | |
| Widow | 5 | 5.00 | 6 | 11.00 | | | |
| Total | 100 | 100.0 | 54 | 100.0 | | | |

Source: Field Survey, 2018

Table 7 shows that level of marital status. It was found that the majority 86% of adopter was married. For non adopter 67% were married. The calculated chi square test value was 403.662 at 4 degree of freedom which was greater than the statistical significant value of 0.05.Additionaly the calculated statistical significant value .000 which was less than the usual statistical significant value of 0.05. This implies the result is statistical significant (Mtama (1997) has an effect in production process as it increases labour availability in the household.

### 4.1.6. Respondents' Income per Year

Under this section income per year was assessed. The result is presented as follows

Table 8 : Level of Income per year

| Income | Adopter category | | | | $X^2$ | df | P-value |
|---|---|---|---|---|---|---|---|
| | Adopter (n=100) | | Non-adopter (n=54) | | | | |
| | n | % | n | % | | | |
| <25,000 | 6 | 6.0 | 31 | 57.4 | 12.091 | 2 | .002 |
| 25,000-45,000 | 36 | 36.0 | 10 | 18.5 | | | |
| 46,000-75,000 | 58 | 58.0 | 13 | 24.1 | | | |
| >75,000 | 0 | 0.0 | 0 | 0.0 | | | |
| Total | 100 | 100 | 54 | 100 | | | |

Source: Field Survey, 2018

Table 8 deals with level income per year. During the survey respondents were asked about their estimated income per year. Majority of farmers (58%) who adopted CA had an income 46,000-75,000 birr per year, 36% were in category of 25,000-45,000 and 6% had an income of less than 25,000. The majority (57%) of non adopter farmers were having an income of less than 25,000 per year followed by 24% who had an income of 46,000-75,000 and 19 % who were in a category of 25,000-45,000 estimated income per year. The calculated chi square test value was 12.091 at 2 degrees of freedom which was greater than the statistical significant of 0.05. Additionally, the calculated p value was .002 which was less than the usual statistical significant of 0.05. It is hypothesized that farmers with high income can adopt CA measures easily than farmers with low income level. Accordingly, results show that farmers with high income were more likely to adopt CA compare with farmers to low income.

### 4.1.7. Livestock level population of adopter and non adopter household

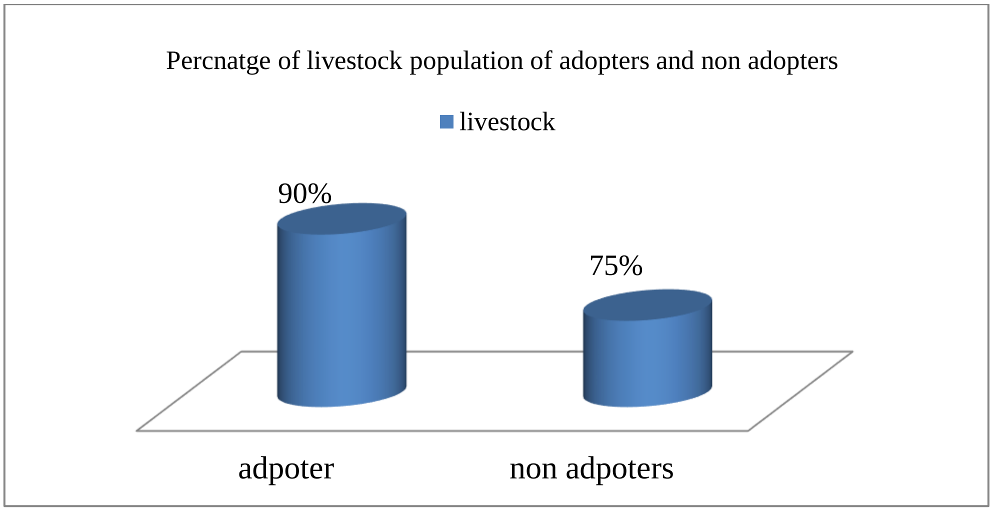



Figure 2: Livestock population of Adapters and Non Adapters

Source: Field Survey, 2018

Fig 2: shows that livestock population of adaptors and non adaptors. Majority of all interviewed households in all kebeles keep livestock such as cattle, goat, sheep and donkey. Disaggregated data among households showed that proportion of adopter households who are keeping livestock is larger (90%) than non adopters (75%). This indicates that livestock keeping is not necessarily a negative intervention for CA farmers, given proper management. Field observation and discussion with farmers indicated that some of the adopters have opted to keep livestock for getting manure that could be applied on their fields to increase soil fertility. It was also found out that the proportion of non adopter households who chose not to keep livestock is larger than that of adopters. The current livestock in the study area is over half of the farmers (adopter and non adopter) have cattle, and not less than that of the CA farmers have cattle. In general, CA farmers have more livestock than non-adopter farmers.

### 4.1.8. Farming Experience

Farming experience is one of the characteristics of respondents which is included in the study. The result from the field survey presented as below.

Table 9 : Farming experience of respondent households

| Farming experience | Adopter category | | | | $X^2$ | df | P-value |
|---|---|---|---|---|---|---|---|
| | Adopter (n=100) | | Non-adopter (n=54) | | | | |
| | n | % | n | % | | | |
| 8-20 | 23 | 23.00 | 0 | 0.00 | 9.117 | 4 | .058 |
| 21-30 | 29 | 29.00 | 8 | 15.00 | | | |
| 31-40 | 30 | 30.00 | 11 | 20.00 | | | |
| 41-50 | 7 | 7.00 | 15 | 28.00 | | | |
| 50+ | 11 | 11.00 | 20 | 37.00 | | | |
| Total | 100 | 100.00 | 54 | 100.00 | | | |

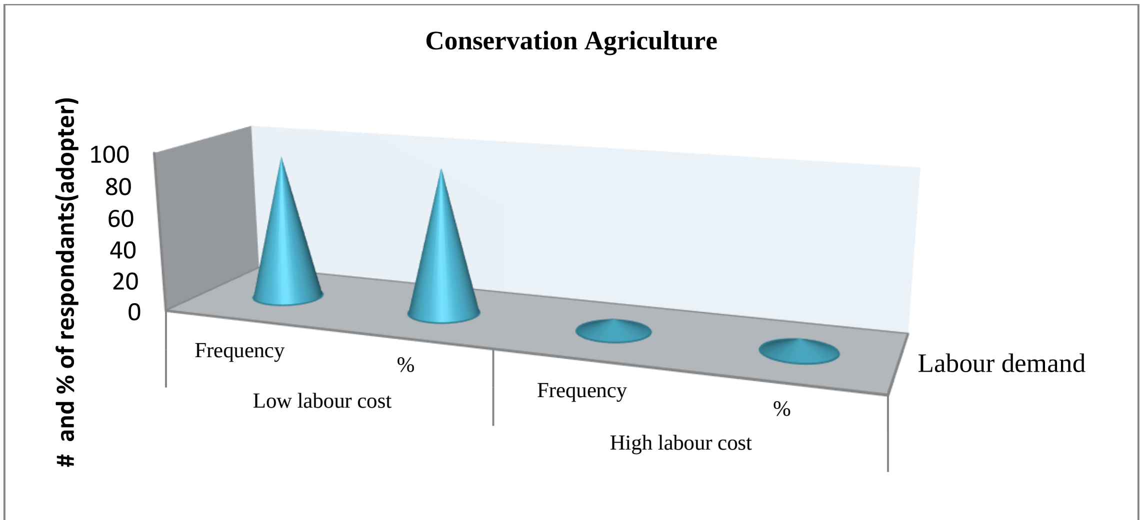
Source: field Survey, 2018

Table 9: depicts that farming experience of respondents. Pertaining to farming experience 30(30%) of conservation agriculture adopted respondents have farming experience of 31-40 years, 29(29%) of the respondents were in the age category of 21-30, 23(23%) of the respondents were in age category of 8-20 years while 20(37%) non adopter respondents were in age of $50^+$ and also 15(28%) of non adopter of respondents were in the age category of 41-50. Moreover, the calculated chi square tests value of 9.117 at 4 degree of freedom. Additionally, the calculated p- value was .058 which is not statistically significant. Thus, it is possible to infer that the study found that farming experience had negative significant relationship with their adoption of improved practices in maize cultivation. On account of farmers views farming experience had no relationship with their use of communication media for receiving agricultural information and awareness regarding conservation agriculture. The

same finding was reported by Sarker (1997) found that experience of potato growers had no significant relationship with their adoption of improved potato cultivation practices.

### 4.1.9. Labour

Labour demand was the issue which is considered in this study. The data which was obtained from the field presented as follows.




| | Low labour cost | | High labour cost | |
|---|---|---|---|---|
| | Frequency | % | Frequency | % |
| Labour demand | 92 | 92 | 8 | 8 |

Figure 3: The level of Labour demand of respondents

Source: Field Survey, 2018

Fig 3: shows the labour force demand need to employ by farmers for the most common cropping system such as maize intercropping with beans. The only difference is in the time employed to accomplish each operation during the long season and short season. According to the respondents CA method reduces the amount of work required in all the operations except for planting. Form the above findings it is possible to infer that 92(92%) of the respondents reported that labour is not demanded in cropping system operation time while 8(8%) reported that labor cost is demanded to practice CA. Form the above information it is possible to say according to respondents CA reduced labour cost per hectare due to the practice of CA.

#### 4.1.10. Farmers' Perceptions

Farmers noticed an increment in their crop yields and erosion was reduced due to the practice of CA. CA improved the quality of the crop, especially for maize, the main reasons for the low adoption of CA were the high price of herbicides and lack of information and knowledge (knowhow), CA decreased the labour requirements and the use of herbicides was needed or even "mandatory" in order to undertake CA.

The study further investigate why some farmers adopt CA and others not. Labour intensiveness, lack of training, and lack of capital to invest in new technologies were the main constraints for farmers not to adopt in the study area. Lack of training, poverty, and land ownership were the main reasons for farmers not to adopt CA technologies. Farmers are hesitant to invest in labour on new technologies such as large pits and terraces on hired farms that they are not sure of continuing to farm in the subsequent season. Other reasons for non-adoption were lack of interest, lack of incentives, and time constraints. In addition, availability of farm inputs, costly implements, low returns, and lack of land for implementing the technologies were also reasons mentioned by farmers.

The reasons for positive perception about CA among farmers were related to increases in crop yields and better utilization of labour and time for farm operations (Shetto *et al*., 2007).

## 4.2. Institutional Support Services Provided to Sample Households

### 4.2.1. Extension service

Extension service play great role to promote conservation agriculture practices. Farmers may obtain information about conservation agriculture from extension service and other media like radio, word of mouth of friends (family).conservation agriculture is modern agriculture that needs great attention in the period of environmental related risks. To promote the practice extension play big role. Taking this in to serious attention this study has tried to investigate the extension service practice of the study area.

Table 10 : Farmers' Level of Access to Extension Service

| Level of farmers access to extension services | | Adopter category | | | | $X^2$ | df | P-value |
|---|---|---|---|---|---|---|---|---|
| | | Adopter (n=100) | | Non-adopter (n=54) | | | | |
| | | n | % | n | % | | | |
| Extension service is source of information about CA | Yes | 99 | 99.00 | 53 | 99.00 | 96.040 | 1 | .000 |
| | No | 1 | 1.00 | 1 | 1.00 | | | |
| Total | | 100 | 100 | 54 | 100 | | | |
| Radio used to gain Information about CA | Yes | 95 | 95 | 34 | 63.00 | | | |
| | No | 5 | 5 | 20 | 37.00 | | | |
| Total | | 100 | 100.00 | 54 | 100.00 | | | |

Source: field Survey, 2018

Table 10 showed that level of farmers' extension service. Regarding the level of extension service to adopt conservation agriculture 99(99%) of the adopter respondents reported that extension service is source of information about CA while 53(98%) of the non adopters respondents reported that extension service is access to extension services. Furthermore, 95(95%) of adopters respondents reported that radio use to gain information about CA while 34(63%) of the non adopter respondents reported that used to gain information about CA. Furthermore, the researcher tried to test the result. The calculated chi square test value was 96.040 at1 degrees of freedom. Additionally, the calculated p- value was .000 which was less than the usual statistical significant value of 0.05.The implies that the result is statistically significant.

#### 4.2.2. Access to credit

In literatures it has been argued that lack of credit is a constraint to the adoption of new technologies (Langyintuo and Mulugeta, 2005). So, lack of capital hinders the farmer from adopting the technology, particularly resource poor farmers. Adoption of new technology with complementary inputs require considerable amount of capital for purchase of inputs (seedlings, fertilizer, etc). Farmers who have access to formal credit are more probable to adopt improved technology than those who have no access to formal credit (Yishak, 2005). On the other hand, the availability of farm credit especially from formal sources is vital component of the modernization of agriculture and to increase productivity. Those farmers who have access to agricultural credit are believed to adopt technology more than those who have no access to credit.

**Table 11: Respondents Report on Credit Access**

| Variables | Adopter category | | | | | $X^2$ | Df | P-value |
|---|---|---|---|---|---|---|---|---|
| | Response | Adopter (n=100) | | Non-adopter (n=54) | | | | |
| | | n | % | n | % | | | |
| **Credit service** | Yes | 89 | 89 | 31 | 57.00 | 48.026 | 1 | .000 |
| | No | 11 | 11 | 23 | 43.00 | | | |
| Total | | 100 | 100 | 54 | 100 | | | |

Source: Field survey.2018

Table 11 shows that access to credit. Regarding to this, 89(89%) of the adaptors category of respondents reported that the presence of credit service and 11(11%) of adopter respondents reported that absence of credit service while 31(57%) of the non adopter respondents reported presence of credit service and 23(43%) of the non adopter respondents reported that absence of credit access. The calculated chi square value was 48.026 at 1 degree of freedom. Additionally the calculated p- value was .000 which was less than the usual statistical significant value of .05 this implies that the result is statistically significant.

### 4.2.3. Organizational Membership

Under this section effort is exerted to assess organizational membership of respondents. The main organizations in the area are unions, service cooperatives and other social institutions. The data obtained from field survey presented as follows.

**Table 12: Level of Organizational Membership of Respondents**

| Variable | Category | | | | $X^2$ | df | P-value |
|---|---|---|---|---|---|---|---|
| | Adopter (n=100) | | Non-adopter (n=54) | | | | |
| | n | % | n | % | | | |
| Organizational membership | 94 | 94.00 | 37 | 68.00 | 75.740 | 1 | .000 |
| | 6 | 6.00 | 17 | 32.00 | | | |
| Total | 100 | 100 | 54 | 100 | | | |

Source: Field survey, 2018

As shown in table 12, about 94% of adopter respondents were found to be a member of some of the rural organizational structure in the study area and 6% of the adopter respondents reported as they are not member of an organization. On the other hand, 68% of the respondents are the member of organization and 32% non adopter respondents were not member of respondents. Furthermore, the result was tested by chi-square test .the calculated chi square was 75.74 at 1 degree of freedom which was greater than the statistical significant value. Additionally, the calculated p- value was .000 which was less than the usual statistical rejection threshold value of 0.05.This implies that both of adopter and non adopter were member of organization as well the result is statistically significant.

## 4.3. CA Information

### 4.3.1. Practice of Conservation Agriculture before the Project

The researcher tried to investigate whether there is the practice of CA before the project is in the study area. Based on observation and interview made with farmers practice of minimum tillage and crop residual is not practiced in the project area. Contrary to this, practice of crop residue retention was practiced to some extent. Accordingly, 26 (17%) the respondents assumed the experience of practice of crop rotation, none of them said that the practice of minimum tillage. In other side, 8(5%) of the participant have experience of practice of crop residual retention.

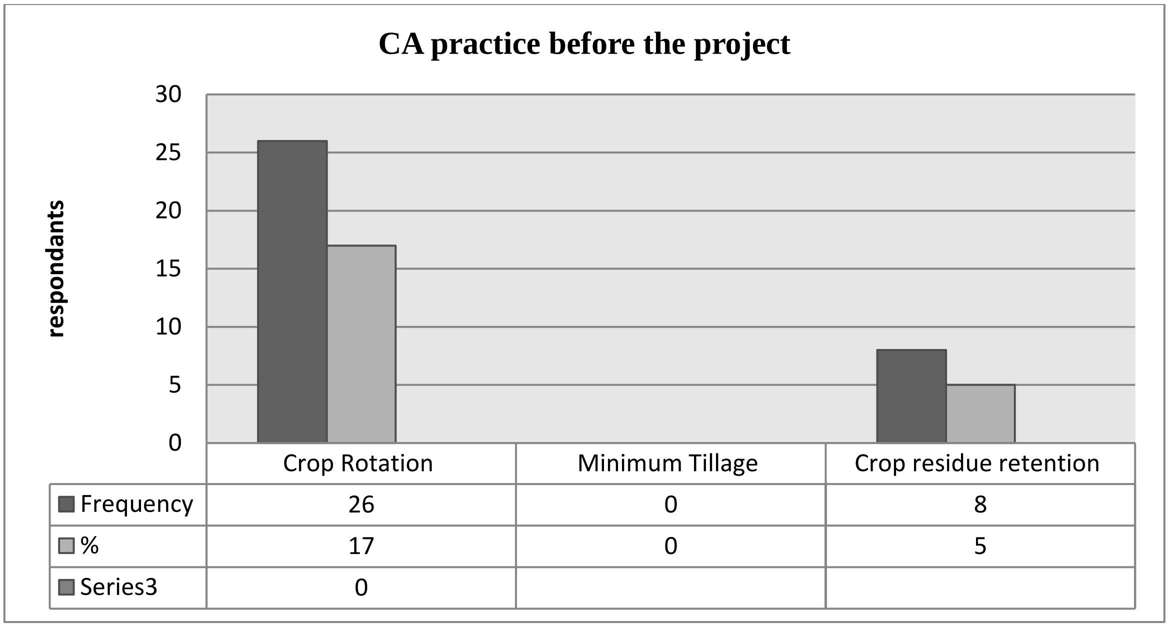



Figure 4: Practice of CA before project

Source: field Survey, 2018

### 4.3.2. Level of Adoption of CA

The adoption rate of CA in the study area is increasing in every year. CIMMYT (2017) reported that the number of farmers adopting CA in Gimbi was 640 from five villages in three years this is from 2015-2017. During the first year only 111 farmers adopted CA, second year there were 150 farmers who adopted CA and the third year 379 farmers adopted CA from the year of 2015-2017. This trend is a proof that there is an increase of adopters of CA in every year. The trend of adopting CA is increasing every year although not in a high rate.

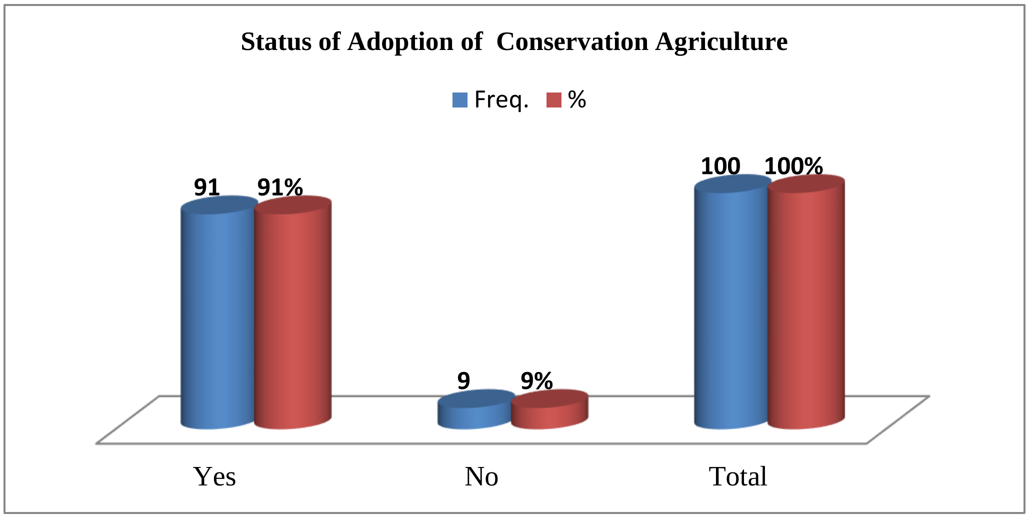



Figure 5: Farmers who adopt CA

Source: field Survey, 2018

### 4.3.2. Reason for Farmers to Adopt

Fig 6**:** Show that 29% of the respondents said that they decided to adopt CA because they wanted to increase crop production. CA through its major three techniques helps to increase crop production. The finding consistence with Shetto and Owenya (2007) claimed that CA helped to increase crops yield in Tanzania, where by maize yield increased from 26%-100% and sunflower for 360%, while in Arumeru and Karatu the increase of maize yield was 60-70%.

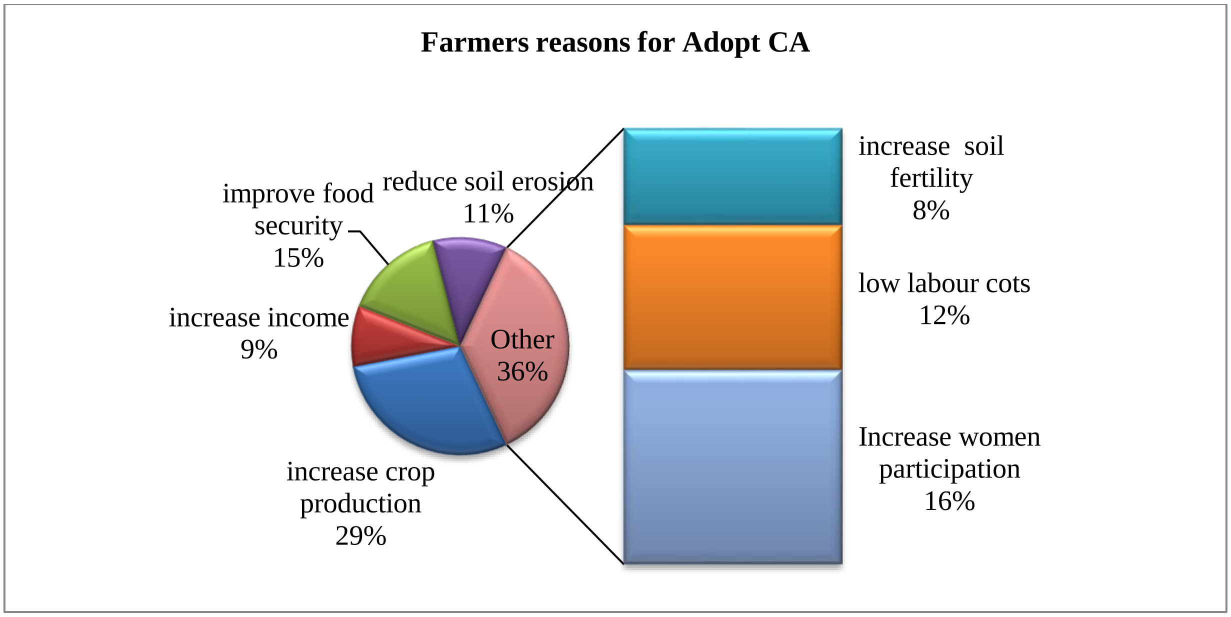



Fig 6: Farmers reason for adopt CA

Source: field Survey, 2018

The reason which made farmers to adopt CA is to increase income. 9% respondents agreed that they adopted CA because they wanted to increase their income. When CA was introduced aiming at increasing community level of income through money and material, increasing community income through their social funds and to give out loans to members for their development (CARE 2008). Therefore for a farmer to get loan he or she must be a member of CA. Since CA increases production the increase in crop yield will increase farmers' income. It was found that 15 % of farmers adopted CA because they wanted to improve food security. ICRAF and ACT (2006) emphasized that there is a reason to believe that CA will help to improve food security in sub-Saharan Africa. Early adopters in any technology are acting as role models therefore many farmers might adopt new technology after seen the benefits that early adopters get. The study show that 11% decided to adopt CA in order to reduce soil erosion and 8% increase soil fertility because exposing soil to the sun and rain leads to crusting, runoff, soil erosion and degradation therefore CA can be used to soil fertility and also12% and 16% of labour cost can be reduce by practicing CA and women participation increases due to practicing CA technology respectively. So it possible to suggest that CA contributes to the reasons for farmers to adopt CA

### 4.3.3. Reasons for farmers not adopting

Non adopters of CA were asked to mention reasons as to why they did not adopt CA despite many visible benefits.

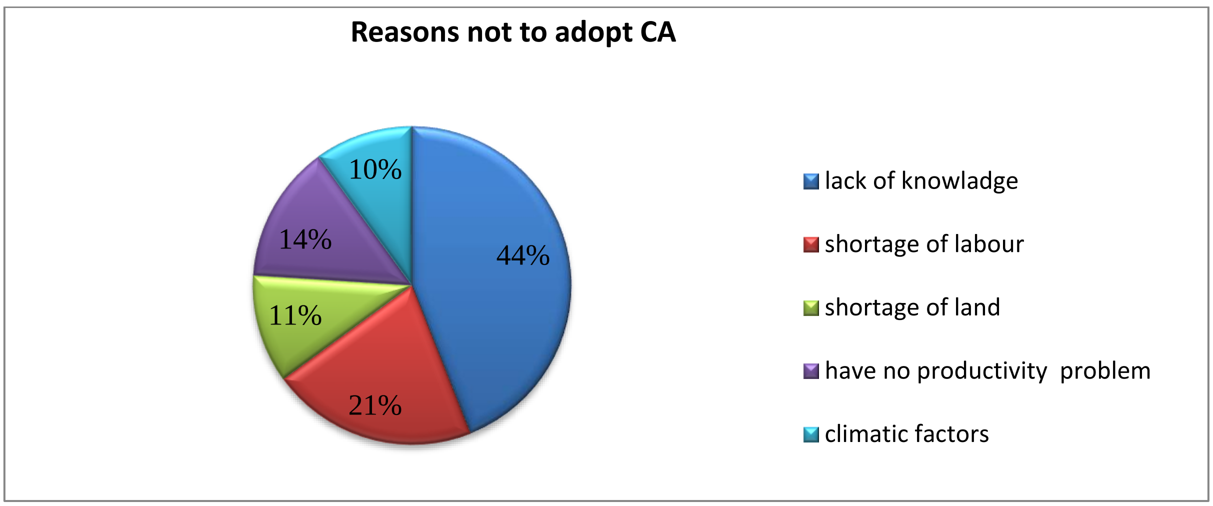


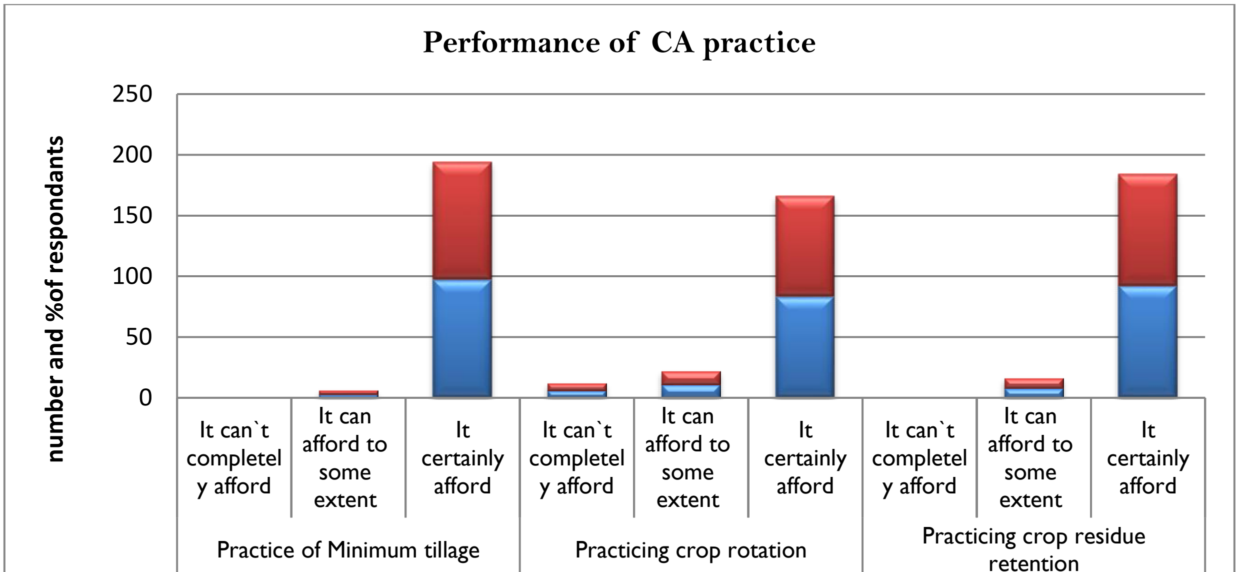

**Figure 6: Reasons for farmers not adopting CA**

Source: Field survey, 2018

Fig 6: shows that reasons for farmers not to adopt to CA. Regarding to this the majority (44%) said that lack of knowledge was the reason for them not to adopt CA. Apart from that the findings also show that (21%) of the respondents said that they did not adopt CA because of shortage of labour. The size of the family determines the number of people who are able to work. These farmers also argued that during the early stage of CA needs enough labour, subsoiling and double digging want a farmer to have enough laboures, but this is only done once after three years. These results are similar with the study conducted by Haggblade and Tembo (2003), who argued that the labour requirements during the establishment stage of pot holing could be double the labour requirements during the later stage on the same piece of land. This shows that the relationship between CA practices and labour is expected to be positive or negative depending on the stage of establishment. It was found that11% of the respondents said that land ownership and shortage of land were the reasons for them not to adopt CA. This finding is consistent with (feder *et al.,* 1983; Akudugu *et al.*, 2012) that large scale farmers are more likely to adopt new technology than small scale farmers. This is also supported by Thangat *et al*. (2002), large farm size gives a farmer the capacity to use land intensive conservation practices such as crop rotation. In this study the farm size may be one of the reasons that made farmers adopting CA. Furthermore the findings show that14% of the respondents said that have no problem in productivity was the reason for them to refuse adopting CA. farmers perception have no knowledge about CA in the study area plays a great role in determines not to adopt CA. It was found that 10% respondents claimed that changes in weather made them not to adopt CA, the climatic factor have the major influence in adopting CA, the amount of rain and its distribution were the most factors that made them not to engage themselves in CA. From the above information it is possible to infer that lack of knowledge was a major reason to adopt CA.

### 4.4. Performance of Conservation Agriculture Project

Under this section performance of CA project is assessed. The performance assessment was made in terms of practicing minimum tillage, practicing crop rotation and practicing residue retention. Before the assessment about performance of CA agriculture, the researcher tried to explore the area of farm land allocated to CA and which technology applies completely.




| | It can`t completely afford | It can afford to some extent | It certainly afford | It can`t completely afford | It can afford to some extent | It certainly afford | It can`t completely afford | It can afford to some extent | It certainly afford |
|---|---|---|---|---|---|---|---|---|---|
| | Practice of Minimum tillage | | | Practicing crop rotation | | | Practicing crop residue retention | | |
| % | 0 | 3 | 97 | 6 | 11 | 83 | 0 | 8 | 92 |
| frequancy | 0 | 3 | 97 | 6 | 11 | 83 | 0 | 8 | 92 |

Figure 7: Performance of Conservation Agriculture practice

Source: field Survey, 2018

Fig7: shows that performance of CA. Some of the conservation agriculture practiced in the study area is minimum tillage, crop rotation and residue retention. Regarding this there is a practice of minimum tillage. It was further observed that crop rotation principle is practiced by the majority of farmers in the study area. This is confirmed by 97% respondents certainly afford while 3% of the respondents reported as it can afford to some extent practice of minimum tillage. Thus, from the above information was practiced by all adopter households. The other CA practice in the study area was practicing crop rotation. Regarding to this, 83% of the respondents confirmed the practice of crop rotation and CA method. While 11% of the respondents reported that crop rotation it can afford to some extent practice as CA means and 6% it shows that practice of crop rotation cannot completely afford.

Finally, in this study effort has been exerted to examine practice of crop residue retention as method of CA. Regarding to residue rotation as conservation agriculture, 92% of the respondents reported that residual retention certainly afford while 8% of the respondents reported that crop residual retention it was afford to some extent.

### 4.4.1. Benefits of Conservation Agriculture

According the interviewee farmers that were completely confirmed that the advantages of CA and expressed clear intentions of continuing with the method as well as integrating it to larger parts of their agricultural land. The success of the project implementation is promising in the side of farmers.

The interview conducted with farmers who participated in the case project, the researcher identified factors that were importance for them and to decide whether or not to adopt CA. Among the benefits of CA were a decrease in labour needs, and features related to soil fertility and prevention of soil erosion, specially minimum tillage has benefit of minimum labour power need, helps to facilitate women participation, helps to reduce production cost, avoid residing, reduce soil erosion, reduce fertilizer cost, control weed, pest control and Structural incentives to decrease opportunity costs of crop residue must be considered. On the other side, some other study confirmed that CA has advantage of less erosion possibilities, better water conservation, improvement in air quality due to less emission being produced, and a chance for larger biodiversity in a given area. Producers will find that the benefits of CA will come later rather than sooner (Chivenge et al., 2007; their felder and Wall, 2009).Since CA takes time to build up enough organic matter and have soils become their own fertilizer; the process does not start to work over night. But if producers make it through the first few years of production, results will start to become more satisfactory. Improved soil quality and improved nutrient cycling with CA will improve the resilience of crops to adapt to changes in local climate change while drought tolerance can be increased in some areas with CA (Hobbs and Govaerts, 2010).

There are unique aspects of study which makes generalizing almost impossible. However, I do believe there are aspects of this study that may be relevant for CA and relate study and practice, and some findings that can add to existing knowledge. One of the most interesting finding has been how the farmers showed real willingness to try CA and to experiment with a new and unfamiliar method. My experience from this study is that many farmers are eager to learn and adopt new agricultural practices, and to use new techniques and technologies that may be beneficial for themselves and the environment.

#### 4.4.2. Conservation Agriculture and Performance of Extension Service

Conservation agriculture needs to be supported by extension service for better output to conserve farm land and to bring climate smart agriculture practice. In this section effort was made to examine conservation agriculture and performance of extension service. Training and capacity building before and throughout the cropping season, multiple trainings and monitoring were conducted by CIMMYT staff to support the local extension agents, DFN staff, and hosting farmers.

Table13: Performance of Extension Service

| Frequency | Adopter (n=100) | Non-adopter (n-54) | Total sample (n=154) | $\chi^2$ | P-value |
|---|---|---|---|---|---|
| **Once a month** | 28(28%) | 32(60%) | 60(38%) | 16.260 | .000 |
| **Twice a month** | 52(52%) | 14(26%) | 66(43%) | | |
| **Trice a month** | 20(20%) | 8(14%) | 28(18%) | | |

Source: field Survey, 2018

Distribution of households by frequency of contact with DA, regard to the CA performance and extension contact, 28%, 52%, 20% of CA adopter contacted or being visited once, twice and trice per month respectively by DAs. In contrast, from non-adopter, 60%, 14% and 66% were contacted by DAs once, twice and trice per month in survey year respectively (Table 13). Moreover, the result depicts that the calculated chi square was 16.260 which was greater than 0.05. The calculated p-value was .000 which was less than the usual statistical rejection threshold value of 0.05. This implies there is statistical significance. The result was accepted.

Households who were more frequently visited by the development agents show differences in accepting CA better than those with less frequently visited. This agrees with Adams (1982) who concluded that techniques or innovations normally provide the means of achieving sustained increases in CA technology to increase farm productivity and incomes of HHs and that it is the extension workers job to encourage farmers to adopt innovations of proven value. Furthermore, extension service contact trend and training of CA compared with previous year is increasing. In addition, respondents have got training three times since inception of CA. Finally the respondents reported that training has contribution for Conservation agriculture.

### 4.4.3. Perception of farmers maize harvest data from adopter and non-adopter.

In this section shows that we can assess the yield variability by regrouping the farmers into two categories, Group 1: Farmers having yield gain in CA technology Group 2 No significant yield gain between CA and non CA. Group 3: farmers having CA practices no yield increase.

Table 14: Percentage of yield difference between CA and conventional practices

| # | Yield difference between adopter and non-adopter | Number of adopter | Average yield difference |
|---|---|---|---|
| 1 | **10-35%** | 61 | +31% |
| 2 | **1-9%** | 27 | +5% |
| 3 | **0%** | 12 | 0% |

Source: field Survey, 2018 computed by SPSS

Table 14 shows that yield difference between CA and non CA practices. According to farmers expressed as, 61 farmers had an average yield potential increase of 31% due to CA practices, however, 27 farmers experienced some yield increase of 5% due to CA practices and 12 farmers had no yield increase. The biggest learning from the yield analysis is that the majority of the farmers confirmed that yield is increased due to the practice of CA. Moreover, the farmers experienced yield reduction due to the prevalence of weeding, disease or other factors.

## 4.5. Contribution of CA towards Climate Change adaptation and related problem

Conservation agriculture is coping strategies (mechanisms) to climate change impacts. Under this section effort is made to assess whether the participant household practice CA is practiced or not before the project implemented in the study project. CA's practices resilience against heavy rain , strong wind, resilience to drought and how long term fertility increase benefits the farmers in form of less fertilizer dependency. Other researchers also confirmed that less erosion possibilities, better water conservation, improvement in air quality due to less emission being produced, and a chance for larger biodiversity in a given area. Producers will find that the benefits of CA will come later rather than sooner (Chivenge et al., 2007; Thierfelder and Wall, 2009) since CA takes time to build up enough organic matter and have soils become their own fertilizer, the process does not start to work over night. But if producers make it through the first few years of production, results will start to become more satisfactory. Improved soil quality and improved nutrient cycling with CA will improve the resilience of crops to adapt to changes in local climate change while drought tolerance can be increased in some areas with CA (Hobbs and Govaerts, 2010).

Agricultural production, including access to food in many African countries, is projected to become severely compromised by climate change (Below et al., 2010). This arises from the fact that African agriculture is mainly rain-fed, and the areas suitable for agriculture, the length of growing seasons and yield potential, particularly along the arid and semi-arid areas, are all expected to decrease. Therefore, adaptation is a key factor that will shape the future severity of climate change impacts on productivity (Lobell et al., 2008).

### 4.5.1. Conservation Agriculture as a means to Climate Change Adaptation

The key finding related climate change adaptation were there are a number of household indicates that agricultural practices and investment that can contribute to both climate change adaptation, a private benefit and less vulnerability. For instance, a striking feature of many conservation agriculture and sustainable land management is the many of these activities also increase the amount of carbon sequestered in the soil; including minimum tillage, by using cover crop and crop rotation. Thus, there are a long term benefits to households from adopting such activities in terms of increasing yields and reducing variability of yield, making the system more resilient to changes in climate.

Furthermore, Farmers who participated in the CA project was identified or decided that CA less vulnerability to effects of drought, less erosion, lower soil temperatures, represents a managed adaptation to climate-change's effects of, for example, more intense rain increased daily ranges of temperatures, and more severe periods of drought. Good mulch cover provides 'buffering' of temperatures at soil surface which otherwise are capable of harming plant tissue at the soil interface, thus minimizing a potential cause of limitation of yields. By protecting the soil surface from direct impact by high-energy raindrops, it prevents surface-sealing and thus maintains soil's infiltration-capacity. On the other hand, adopters' perception deals that in CA system, more soil moisture can be conserved than leaving the land as fallow, thus allowing for the introduction of additional crops including cover crops into the system.

In general participants or adopters decided Conservation agriculture was practiced to better ecosystem functioning and services and to improve agricultural productivity. Moreover, poor protection of natural resource conservation and agricultural practice may cause natural catastrophe like climate change .his natural problem can be managed or controlled by practicing different coping mechanisms. Thus, it possible to suggest that conservation agriculture one of the coping mechanism and it contribute to the climate change adaptation.

### 4.5.2. Conservation agriculture and Impact of Climate change on Agricultural Production

Climate change has complex effects on the bio-physical processes that underpin agricultural systems, with both negative and positive consequences. Rising atmospheric CO2 concentration, higher temperatures, changes in annual and seasonal precipitation patterns and in the frequency of extreme events has affect the volume, quality and stability of food production and the natural environment in which agriculture takes place. Climatic variations have consequences for the availability of water resources, pests and diseases and soils, leading to significant changes in the conditions for agriculture and livestock production. In extreme cases, the degradation of agricultural ecosystems could mean desertification, resulting in a total loss of the productive capacity of the land in question. Although climate change is a global process, its local impacts are diverse (CEC, 2009).

In this section extreme events are assessed in the study area related with some of the extreme events are drought, flood, too much rainfall, late rainfall, strong wind, livestock disease, crop disease, extreme heat; the results also summarized as follows:

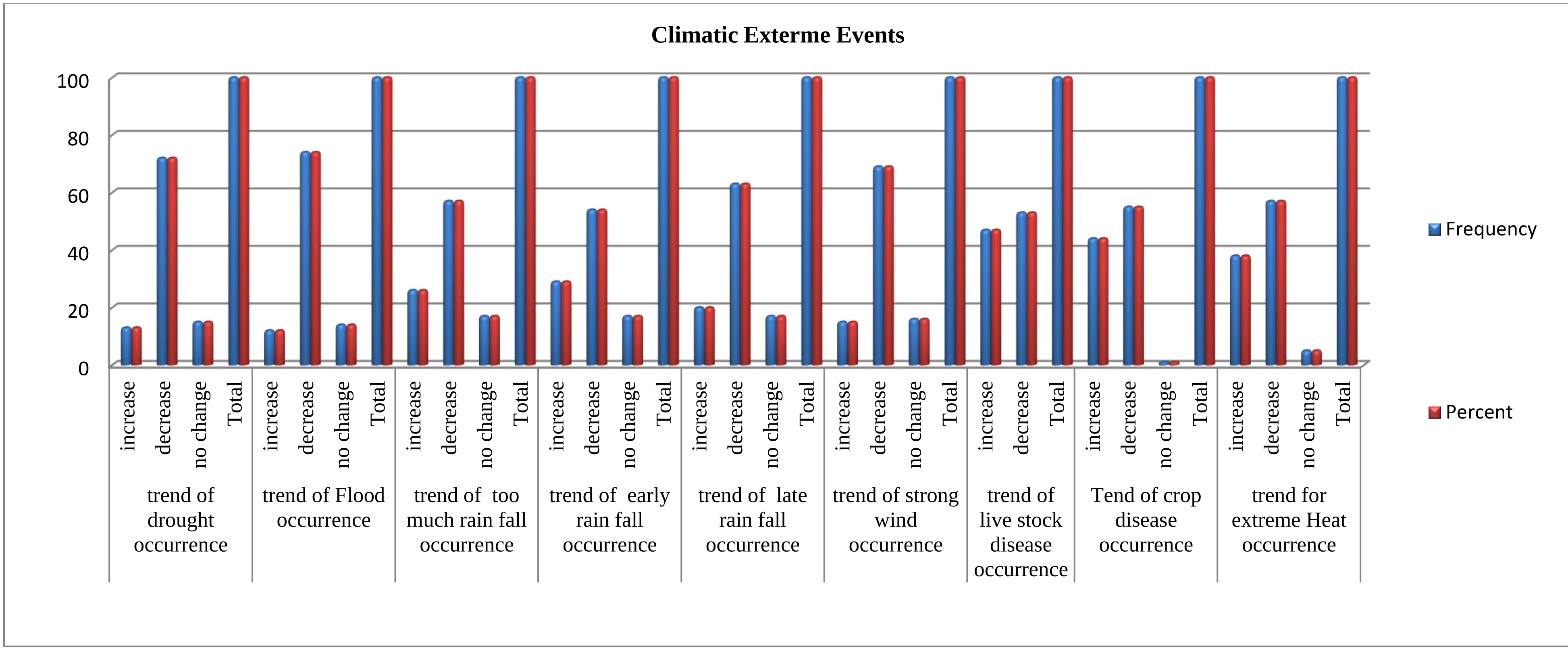



Figure 8: Impacts of Conservation agriculture and climate risk occurrence

Source: Field survey, 2018

This section deals with the farm-level climate change adaptation strategies used by the respondents during 2015 cropping year. Majority of the respondents (92%) used multiple crop types/varieties as a crop management practice and mulching as a crop and soil management practice was used to adapt to climate change. On the above information the result shows that according to framers climate change perception, the respondents perceived that there was lower temperature, decreased livestock disease, decrease crop disease and decrease rainfall delayed/erratic rainfall in the study area; the extreme events were decreasing due to the practice CA in last three years.

Adaptation to climate change involves changes in agricultural management practices in response to changes in climate conditions. It often involves a combination of various individual responses at the farm-level and assumes that farmers have access to alternative practices and technologies (Nhemachena & Hassan, 2007).

### 4.6. Challenges of Conservation Agriculture

Information from CA adopter, the challenges of conservation agriculture in the study project was summarized as follows. The challenges include high input costs, low input availability, and possibly low biomass access and associated high opportunity costs for crop residue. The project was successful in efficient dissemination of knowledge and relatively high awareness of about the various elements and effects of CA.

Farmers expressed a clear intent to continue with CA and implement it on a long term basis. They wanted to be independent and keep doing the method regardless of external aid or input subsidies. Technologies that allow control of infestation by termites, stem borers and pests, are also needed. As several of the farmers reported, termites and stem borers can be a real problem that may be detrimental to crops. Also, when mulching is implemented, farmers may face problems with infested residue that causes transfer of pests from one season to the next.

Still, the most important barrier towards sustainability and long term adoption are arguably input constraints. The farmers spoke with viewed inputs as the single most constraining factor. Farmers complained about the prices of fertilizer, and about how they were unable to supply themselves with it on a regular basis. At the same time, they seemed convinced that CA could not be performed without this input, which gives reason to believe that farmers face the choice of either dis-adopting CA, or buying fertilizer at the expense of other necessities in order to continue with CA. In either case there will be large trade-offs involved that, in the absence of subsidized input programmes, are only determined by the farmers' potential space of action and investment possibilities. As previously pointed out, access to seeds are major structural inhibitors to CA adoption

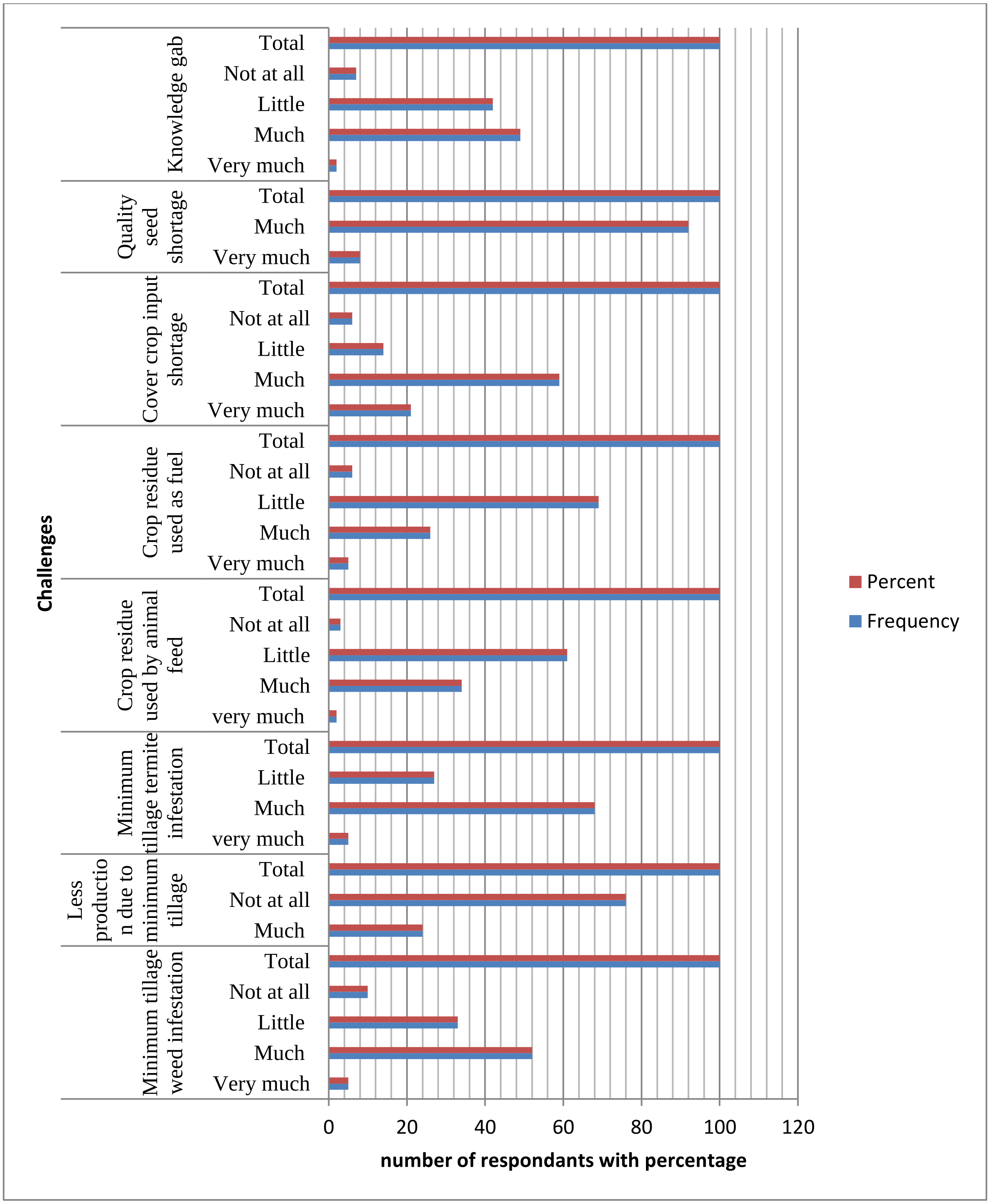



Figure 9 : perceptions of farmers on the challenges of conservation agriculture practice

Source: Field Survey, 2018

Fig 9: showed that distribution of respondents challenges of adoption CA practice. There are different items which is included in the study. According to respondent's reply, the first challenge minimum tillage termite infestation is quality seed shortage, the second challenge is minimum tillage termite infestation, the third challenge is cover crop input shortage; minimum tillage weed infestation is the fourth; the fifth challenge was knowledge gap, the sixth challenge is crop residue used by animal feed. Lastly, the farmer rank crop residual used as the challenges to adopt CA in the study area. Generally Challenges of Conservation Agriculture

information from CA adopter, the main challenges include high input costs and low input availability.

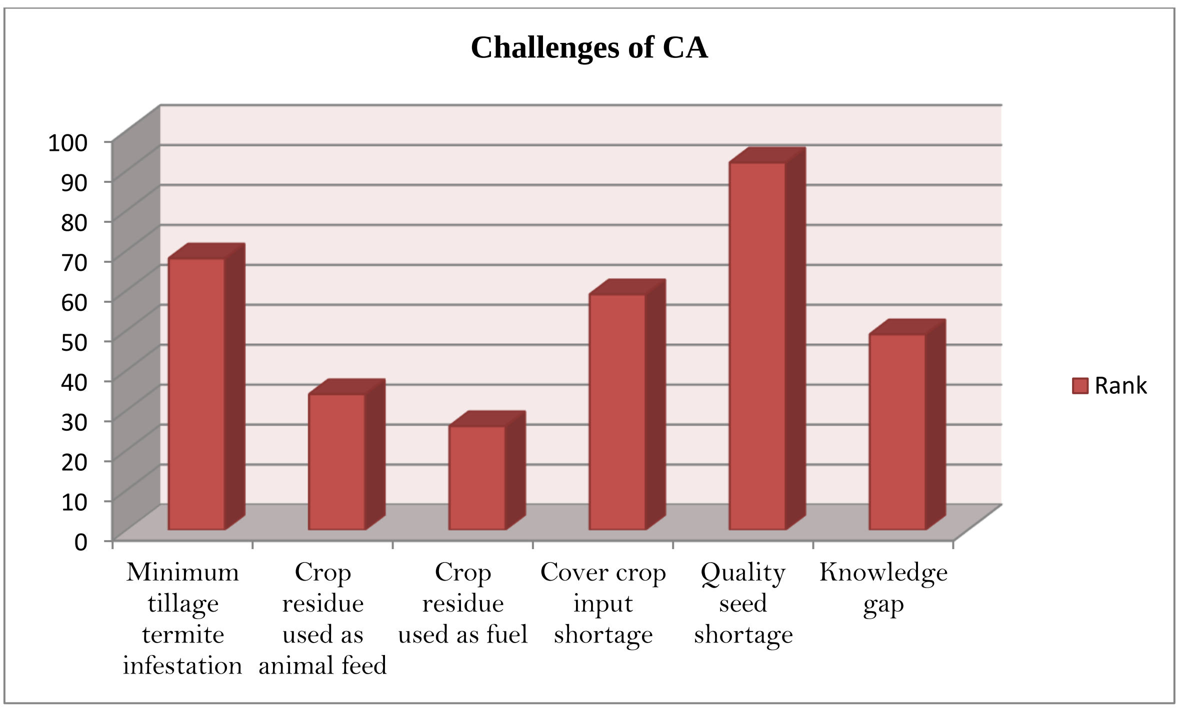



Figure 10 : perceptions of farmers on the challenges of conservation agriculture practice

Source: Field Survey, 2018

# CHAPTER FIVE

## 5. Conclusion and Recommendation

### 5.1. Conclusion

The purpose of this study was evaluated the performance and contribution of conservation agriculture towards climate change adaptation in the case of Gimbi pilot project.

- Performance of conservation Agriculture (CA) practices including minimum tillage, legume intercropping, crop rotation and climate related information.
- Conservation agriculture (CA) is more resilient to climate variations. The components comprising CA include minimum-till farming, permanent soil cover and crop rotations which have existed for nearly four year and the uptake has generally been high.
- The rates of adoption of conservation agriculture have remained particularly high in the study area.
- CA is widely promoted for reducing soil degradation and improving agricultural sustainability in the study area, CA less vulnerability to effects of drought.
- Adopters decided CA was practiced to better soil ecosystem functioning and services and also it contributes to environmental conservation as well as to enhance and sustained agriculture to improve agricultural productivity.
- Conservation agriculture has a potential to be resource efficient and resource effective agriculture specially Improvements of water use efficiency particularly contribute to resilience in the face of drought.
- CA system, more soil moisture can be conserved through integrated management than leaving the land as fallow.

- It is also claimed to mitigate climate change through soil carbon sequestration, good mulch cover provides 'buffering' of temperatures at soil surface, increased biological activity and increase soil fertility.
- Farmers become aware of an increment in their crop yields and erosion was reduced due to the practice of CA.
- The performance of adopter farmers the yield of maize on CA practices differs significantly from the non-adopter group yield of maize. Maize is a major staple food crop and is critical for ensuring food security in the study area.
- According to this analysis, 61 farmers had an average yield potential increase of 61% due to CA practices, however, 27 farmers experienced some yield potential increase of 27 % due to CA practices and 12 farmers had yield penalty of 12% due to other factors.
- Within their maize-based systems, the low income smallholder farmers can also produce some grain legumes (e.g. haricot beans) enhancing soil fertility by fixing nitrogen, reduced tillage, improved maize hybrids, maize intercropped or rotated with legumes.
- The biggest learning from the yield analysis is that the majority of the farmers confirmed the positive yield by expressing their interest to continue and even expand the new practices.
- However, the reasons why farmers had no yield reduction need to be further analyzed whether this is due to weeding, disease or other factors.
- Adopter farmers have shown that CA has improved their lives considerably, and of their families; despite all the challenges they faced and managed to overcome to start developing this agriculture method in their fields. Some of these challenges include:

- The main reasons for farmers not to adopt CA technologies include lack of training, land ownership, high price of herbicides, lack of information and knowledge, lack of incentives, availability of farm inputs, costly implements and low returns for implementing the technologies were also reasons mentioned by farmers.
- CA adopters are reported that the challenges of conservation agriculture in the study project were summarized as high input costs, low input availability, and possibly low biomass access and associated high opportunity costs for crop residue.
- Generally the project was successful in efficient dissemination of knowledge and relatively high awareness of about the various elements and effects of CA.

## 5.2. RECOMMENDATIONS

Based on the findings in this study, the following recommendations are made;

- The government and concerned stakeholders should focus on building technical and practical capacity in conservation agriculture and need to be organized capacity building for both extension staff and farmers to improve Conservation Agricultural practices and to improve CA knowledge transfer.
- The government and concerned stakeholders is need to select farmers that are willing to adopt CA and not rely on CA programs for inputs and implements to reduce the levels of climate change and improve sustainability of CA promotion.
- The government and concerned stakeholders allow the involvement of the private sector, especially in agricultural inputs/implement and service delivery that promote CA in a well-coordinated manner at country as well as at the project level should be encouraged. This will improve availability and affordable access to CA inputs and implements.
- The government and concerned stakeholders need to focus on promoting cattle manure use where retention of crop residue is hardly practiced as this could be a better integrated approach and more beneficial where cattle manure is very much available.
- Culturally most farmers use animal draft power for cultivation, hence promotion of ripping for minimum tillage should be encouraged. It is more promising as an adaptive measure. However, where necessary basin making may continue to be promoted, for those ready to practice the technology.

- There is need to integrate Conservation Agriculture within the University and College curriculum. Proper training in CA should be done at college level, to reduce cost of retraining officers once they are employed, as is the case currently.
- Engaging and harmonizing the different departmental programs when dealing with climate change adaptation within the Ministry of Agriculture to reduce duplication of work and enhance efficient use of resources.
- Strengthening policy support especially inputs and crop marketing, to improve CA principle of crop rotation and stimulate crop diversification.
- Strengthening core-decision making with lower and local structures to ensure smooth delivery of CA services.
- Farmers that have access to extension service, visiting demonstration site, training and mass media. This result in increasing the scale of CA practices because CA is a relatively ‘knowledge intensive’ practice. Therefore, extension service should provide to farmers with regard to the CA practice expansion.
- Finally, it is very important to giving serious attention to design policies and strategies that address problems associated with the adoption of CA based CA principles. In general, the strategies should consider improved and disease resistance varieties of seed.

## REFERENCES

ACT (2008), Linking Production, Livelihoods and Conservation. Proceedings of the Third World Congress on Conservation Agriculture, African Conservation Tillage Network 3 - 7 October 2005, Nairobi, Kenya. pp. 45 – 76.

Adjei, E. O., Aikins, H. S., Boahem, P., Chand, K., Dev, I. and Lu, M. (2003). *Combining Mechanism with CA in the Transitional Zone of Brong Ahafo Region in Ghana.* Working document series 108, Ghana. 50pp.

Akudugu, M. A., Guo, E. and Dadzie, S. K. (2012). Adoption of modern agricultural production technologies by farm household in Ghana: What factors influencing their decision? *Journal of Biology, Agriculture and Healthcar* 2(3): 2 – 9.

Amir, T. H, (2006), how to define farmers capacity. *Agricultural Economic Journal* 236(3): 261 – 272.

Amsalu, A. and De Jan, G. (2007). Determinants of adoption and continued use of stone terraces for soil and water conservation in an Ethiopian highland watershed. *Ecology Economics* 61: 294 – 302.

Ayuya, I. O., Lagat, K. J. and Mironga, J. M. (2011). Factors influencing potential acceptance and adoption of clean development Mechanism project: Case of carbon trade tree project among small scale farmers in Njoro district, Kenya. *Research Journal of Environment and Earth Science* 2(3): 275 – 286.

Baidu-forson, J. (1999). Factors influencing adoption of land influencing technologies in Sahel: Lesson from a case study in Niger. *Agricultural Economics* 20(3:) 231 – 239.

Balmford, A., Green, R.E. &Scharlemann, J.P.W. 2005. Sparing land for nature: exploring the potential impact of changes in agricultural yield on the area needed for crop production. *Global Change Biology,* 11(10), 1594–1605.

Berger, A., Fredrich, T. and Kienzle, J. (2008).*Soil Plant Growth and Production.*Rome, Italy. 115pp.

CARE (2008).*Hillside Conservation Agriculture for Improved Livelihoods in the SouthUluguru Mountains, Tanzania*. CARE International, Morogoro, Tanzania. 20pp.

Carney D. 2002. "Sustainable Livelihoods approaches: Progress and Possibilities for change." Department for International Development. London.

Chamberlin, J. & Schmidt, E. 2012. Ethiopian agiculture: A dynamic geographic perspective. In Dorosh, P.A. & Rashid, S. (eds): *Food and Agriculture in Ethiopia. Progress and Policy Challenges.* University of Pennsylvania Press, Philadelphia.

Chivenge P, Murwira H, Giller K, Mapfumo P, Six J (2007). Long-term impact of reduced tillage and residue management on soil carbon stabilization: implications for conservation agriculture on contrasting soils. Soil Till. Res. 94(2)

CIMMTY (1993). *The Adoption of Agriculture Technology:* A guide for survey design. Mexico. 88pp.

CIMMYT, 2016. *Climate Smart Agriculture (CSA) in Oromia region project. Technical report*. International Maize and Wheat Improvement Centre, Addis Ababa.

*Cook, John; Dana Nuccitelli; Sarah A Green; Mark Richardson; Bärbel Winkler; Rob Painting; Robert Way; Peter Jacobs; Andrew Skuce (May 2013). "Quantifying the consensus on anthropogenic global warming in the scientific literature*

*Cook, John; Oreskes, Naomi; Doran, Peter T.; Anderegg, William R. L.; Verheggen, Bart; Maibach, Ed W.; Carlton, J. Stuart; Lewandowsky, Stephan; Skuce, Andrew G.; Green, Sarah A. (2016), "Consensus on consensus: a synthesis of consensus estimates on humancaused global warming", Environmental Research Letters, 11 (44), doi:10.1088/1748-9326/11/4/048002*

Commission of the European Communities [CEC](2009). Adapting to climate change: challenges for the European agriculture and rural areas. *Commission staff working document* accompanying the white paper- Adapting to climate change: towards a European framework for action.

CSA. 2008. *Summary and Statistical Report of the 2007 Population and Housing Census. Population Size by Age and Sex.* Central Statistical Authority, Addis Ababa.

Derpsch, R. (2005). The extent of Conservation Agriculture adoption worldwide: Implications and impact. Proceedings of 3rd World congress on Conservation Agriculture, Nairobi Kenya 3 – 7 October, 2005.

Derpsch, R., Friedrich, T., Kassam, A. and. Hongwen, L.(2010). Current status of adoption of no-till farming in the world and some of its main benefits. International Journal of Agricultural and Biological Engineering, 3: 1-25

FAO (2001). *The Economic Conservation Agriculture*. Food and Agriculture Organization of the United Nations, Rome, Italy. 124pp.

FAO (2008). Investing in Sustainable Crop Intensification: The Case for Soil Health. Report of the International Technical Workshop, Roma, July. Integrated Crop Management. Vol. 6. Rome: FAO. From: http://www.fao.org/ag/ca/. Accessed on 10 May, 2013.

FAO (2011). *Conservation Agriculture Adoption Worldwide.* Rome, Italy, 58pp.

FAO (2011c) CA adoption worldwide. From: (http://www.fao.org/ag/ca/6c.html). Accessed on 9 February, 2014.

FAO Sub regional Office for Eastern Africa. (2009). *Scaling-up Conservation Agriculture in Africa: Strategy and approaches.* Addis Ababa: FAO Sub regional Office for Eastern Africa.

FAO. 2010. “Climate-Smart” Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation. Paper prepared for Hague Conference on Agriculture, Food Security and Climate Change.

FAPDA. 2014. *Country fact sheet on food and agriculture policy trends: Ethiopia* Food and Agriculture Policy Decision Analysis, Rome.

Feder, G., Just, R. E. and Zilberman, D. (2003). Adoption of agricultural innovations in developing countries: A survey. *Economic Development Culture Change* 33 (2): 255 – 298.

Foley, J. (2011). Sustainability: Can we feed the world and sustain the planet? A five-step global plan could double food production by 2050 while greatly reducing environmental damage. *ScientificAmerican* , 60-65.

Friedrich, T., Kassam, A.H. and Shaxson, F. (2009). Conservation Agriculture, in: Agriculture for Developing Countries, Science and Technology Options Assessment (STOA) Project, European Technology Assessment Group, Karlsruhe, Germany.

Fukuoka, M. (1975). One Straw Revolution, Rodale Press, English translation ofshizennohowaraippeon no kakumei, Hakujusha Co. Tokyo, 138.

Gabre-Madhin, E. Z. and Haggblade, S. (2001). *Success in African Agriculture:* Results of an expert survey. International Food Policy Research Institute, Washington DC. 118pp.

Giller, K. E., Witter, E. Corbeels, M. and. Tittonell, P. (2009). Conservation agriculture and smallholder farming in Africa: the heretics' view. Field Crops Research, 114: 23-34.

Govaerts B, Sayre KD, Goudeseune B, De Corte P, Lichter K, Dendooven L, Deckers J (2009). Conservation agriculture as a sustainable option for the central Mexican highlands.Soil Till. Res. 103(2):222-230..

Greenland, D. J. (1975). Bringing the green revolution to the shifting cultivators. Science, 190: 841-844.

Greenpeace, 2008, Snyder CS, Bruulsema TW, Jensen TL, Fixen PE: Review of greenhouse gas emissions from crop production systems and fertilizer management effects. Agric Ecosyst Environ 2008,133:247-266.

Haggblade, S. and Tembo, G. (2003). Early evidence of Conservation Farming in Zambia. *Paper Presented at the International Workshop on Reconciling Rural Poverty and*

*Resource Conservation: Identifying Relationships and Remedies,* New York, 2 – 3 May 2003. pp. 10 – 20.

Harford, N. (2009). *Farming for the Future a Guide to Conservation Agriculture in Zimbabwe.* Zimbabwe Conservation Agriculture Task Force. Harare, Zimbabwe. 126pp.

Hobbs P R. 2007. "Conservation agriculture: what is it and why is it important for future sustainable food production." *Journal of Agricultural Science* 145: 127–137.

Hobbs, P., Gupta, R. and Meisner, C. (2006).*Conservation Agriculture and Its Applications in South Asia*.Cornell University. 70pp

IPCC. (2007). *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Geneva: IPCC.

Johnson, J.M., A.L. Franzluebbers, S.L. Weyers and D.C. Reicosky. 2007. Agricultural opportunities to mitigate greenhouse gas emissions. Environ. Pol. 150:107-124.

Just, R. E., Zilberman, D. and Rausser, G. C. (1980). A putty clay approach to the distributional effects of new technology under risky. In: *Operations Research in Agriculture and Water Resources.* (Edited by Daniel, Y. and Charles, T.), North Holland Publication Amsterdam. pp. 42 – 63.

Lal, R (1976). No tillage effects on soil properties under different crops in western Nigeria. Soil Sci. Soc. Amer. Proc, 40: 762-768.

Lipper, L., Thornton, P., Campbell, B.M., Baedeker, T., Braimoh, A., Bwalya, M., Caron, P.,Cattaneo, A., Garrity, D., Henry, K., Hottle, R., Jakson, L., Jarvis, A., Kossam, A., Mann, W., McCarthy, N., Meybeck, A., Neufeldt, H., Remington, T., ThiSen, P., Sessa, R., Shula, R., Tibu, A. &Torquebiau, E.F. 2014. Climate-smart agriculture for food security. *NatureClimate Change*, 4, 1068-1072.

Lobell DB, Burke MB, Tebaldi C, Mastrandrea MD, Falcon WP, Naylor RL (2008). Prioritizing climate change adaptation needs for food security in 2030. Science 319(5863).

Marrongwe, L. S. , Nyagumbo, I., Kwazira, K., Kassam, A. and Friedrich, T. (2012). Conservation Agriculture and Sustainable Crop Intensification: A Zimbabwe Case Study .Integrated Crop Management. FAO, Vol. 17.

Mattee, A. Z. (1994). Reforming Tanzanians Agriculture Cultural Extension system: *African Study Monographs* 15(4): 177 – 188.

Mazvimavi, K. and Twomlow, S. (2009). Socio economic and institutional factors influencing adoption of conservation farming by vulnerable households in Zimbabwe. *Agricultural Systems* 10: 20 – 29.

McKenzie, F.C. & Williams, J. 2015. Sustainable food production: constraints, challenges and choices by 2050. *Food Security*.7(2), 221-233.

Milder, J. C., Majanen, T. and Scherr, S. J. (2011). Performance and Potential of Conservation Agriculture for Climate Change Adaptation and Mitigation in Sub-Saharan Africa. Ecoagriculture Discussion, Paper Number 6.

Mlonzi, M. R. S. (2005). Efficiency of convectional extension approaches: a case of Morogroro District in Tanzania. *Journal of Continuing Agriculture and Extension* 2(1): 113 – 127.

Morris, M., Rusike, J. and Smale, M. (1998). Maize seed industries: In: *Maize Seed Industries in Developing Countries, Technical Economics, and Policy Issues*. (Edited by Morris, M. and Lynne, R.), Boulder, Colorado, USA. pp. 35 – 54.

Mtama, L. Y. (1997). Factors influencing female-headed households involvement in the Sasakawa global 2000 project in Rukwa Region. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 96pp

Nhemachena, C. & Hassan, R. (2007). *Micro-level analysis of farmers' adaptation to climate change in Southern Africa* . (IFPRI Discussion paper No. 00714). Washington DC, 174 USA: International Food Policy Research Institute (IFPRI), Environmental and Production Technology Division.

Ngigi, S.N. 2009. Climate Change Adaptation Strategies: Water Resources Management options for Smallholder Farming Systems in Sub-Saharan Africa. The MDG Centre for East and Southern Africa, The Earth Institute at Columbia University, New York, 189p.

Nkala, P., Mango, N., Carbeels, M., Veldwisch, G. J. and Huising, J. (2011).The conundrum of conservation agriculture and livelihoods in Southern Africa.*African Journal of Agriculture Research* 6(24): 5520 – 5528.

Norman, D. W. (2005) factors influencing adoption. *Agriculture Economic Journal* 17(3): 139 – 145.

Nyagumbo, I., Mbvumi, B. M., Mutsamba, E., 2009. "CA in Zimbabwe: socio-economic and biophysical studies."A paper presented at the SADC Regional Conference on Sustainable Land Management, Windhoek, Namibia, 7–11 September.

Persevearance, J., Chimvuramahwe, C. and Bororwe, R. (2012). Adoption and efficiency of selected conservion farming technologies in Madziva Communal Area, Zimbabwe. *Bulletin of Environment, Pharmacology and Life Sciences* 1(4): 27 – 38.

Ringler, C., Zhu, T., Cai, X., Koo, J., & Wang, D. (2010). *Climate Change Impacts on Food Security in Sub-Saharan Africa: Insights from Comprehensive Climate Change Scenarios.* Washington, DC: IFPRI.

Rockström, J., Kaumbuthob, P., Mwalleyc, J., Nzabid, A.W., Temesgene, M., Mawenyac, L., Barrona, J., Mutuab, J. &Damgaard-Larsen, S. 2009a. Conservation farming strategies in East and Southern Africa: Yields and rain water productivity from on-farm action research. *Soil Tillage Research* 103, 23-32.

Rukuni, M., Tawonezvi, P., Eicher, C., Munyuki, H. M. and Matondi, P. (2006). *Zimbabwe's Agricultural Revolution Revisited.* University of Zimbabwe Publications, Harare. 155pp.

Serman, N. and Filson, G. C. (1999). Factors affecting farmers' adoption of soil and water conservation practices in Southwestern Ontario. *Paper Presented at the Fourth Biennial Conference of the International Farming System Association,* Guelph, Ontario, Canada. pp. 65 – 138.

Smith J, Smith P, Wattenbach M, Gottschalk P, Romanenkov VA, Shevtsova LK, Sirotenko OD, Rukhovich DI, Koroleva PV, Romanenko IA, et al. Projected changes in the organic carbon stocks of cropland mineral soils of European Russia and the Ukraine, 1990–2070. Glob Chang Biol2007, 13:342–356.

Solvine, E.,1960.slovin's formula for sampling technique. Retrieved on February, 13, p.2013.

Swamson, B. E., Roling, N. and Jigg, E. (1984). Extension Strateges for technology utilization. in agriculture Extension. (Edited by Swamson, B. E.), FAO, Rome, Italy. 106pp.

Thangata, P. H., Hilderbrad, P. E. and Gladwin, C. H (2002). Modelling Agroforestry Adoption and Household Decision Making in Malawi, African Studies Quarterly. *The Online Journal for African Studies.*

Todd RW, Cole NA, Casey KD, Hagevoort R, Auvermann BW (2011) Methane emissions from southern High Plains dairy wastewater lagoons in the summer. Animal Feed Science and Technology, 166–167, 575–580.

UCDavis. (2013). The Davis Statement. Climate-Smart Agriculture Global Research Agenda: Science for Action. *Climate-Smart Agriculture: Global Science Conference* (pp. 1-7). Davis: University of California

Wondwossen, T., Dejene A., La Rovere, R., Mwangi, W., Mwabu, G., and Tesfahun, G. 2008. Does Partial Adoption of Conservation Agriculture Affect Crop Yields and Labour Use? Evidence from Two Districts in Ethiopia. CIMMYT/SG 2000.

Worku, B. 2001. In: Proceedings of the national workshop on conservation agriculture at Melkasa. Organized by SG2000.Melkasa, Nazreth.

World Population Review. 2016. *Review of Ethiopia.* Accessible at: http://worldpopulationreview.com/countries/ethiopia- population/ [Read 20.05.16].

Wozniak, G. D. (1984). The adoption of interrelated innovations: A human capital approach. *Review of Economics Statistics* 66: 70 – 79.

**APPENDIXES**

From Gimbi _CA adoption

Appendix 1: The Description of variables, indicators, and level of measurement

| Variable | Operational Definition | Indicator | Level of Measurement |
|---|---|---|---|
| Age | Number of years Since one was born | Years | Ratio |
| Sex | Biological state of Being a male or a female | 1. Female<br>2. Male | Nominal |
| Marital status | Martial relationship Of the respondent | Married -1<br>Single -2<br>Separated-3<br>Divorse-4 | Nominal |
| Education | Level of education of household respondent | Illiterate -1<br>Primary education-2<br>Read and write only-3<br>Primary school-4 | Ratio |
| Household size | Number of members In a household | Number of members | Ratio |
| Land ownership | Status of land possession by | 1. Owned=1 | Nominal |

| | | | |
|---|---|---|---|
| | household | 2. Hired=2<br>3. Others | |
| Farm size | The size of land possesses by the household | Per acre | Ratio |
| Household income | Amount of money possessed by household | Birr | Ratio |
| Household labour | Number of house hold members who are able to work from 18-50 years | Number of members | Ratio |
| Extension service | Agriculture extension officers provide to farmers | Yes or no | Nominal |
| Adoption | Decision to apply an innovation | 1.number of farmers practicing CA<br>2.number of farmers not practicing CA | Ratio |

**Appendix 2 : Performance of CA and farmers response**

2.1. What is your perception towards CA?

1. Excellent 2. Very good 3. Good 4. Poor

2.2. How do you describe the performance of conservation agriculture in your farm land?

a) It can`t completely afford b) It can afford to some extent c) It certainly afford

2.3. What is the total size of land managed by the household? __________________ha

2.4. Do you practice conservation agriculture?

a) Do you practice minimum tillage Yes =1 and No =2

b) Do you practice crop rotation Yes =1 and No =2

c) Do you practice permanent crop residue Yes =1 and No =2

2.5. How was land for the crop production practices acquired?

Owned: [ ] =1 inherited [ ] 2=gifted Sharecropped [ ] =3 rented [ ] =4

2.6. Types and size of crop land parcels managed by the household

2.7. Number of Family labour engaged on farming:

(a) Do you practice zero tillage or minimum tillage system in your farm before a project?

1= Yes ( ) 2=No ( )

(b) Do you retain crop residue after harvesting of crop before a project? 1=Yes [ ] 2=No [ ]

(c) Do you practice crop rotation on your farm before a project? 1=Yes ( ) 2=No ( )

2.8. Problem faced by the farmers in practicing CA and perception on benefits

2.9. Please indicate the extent of hindrance caused by the following problems in the adoption of CA practices.

| No | Problems | Extent of hindrance caused in farming | | | |
|---|---|---|---|---|---|
| | | very much | Much | little | not at all |
| 1 | Minimum tillage | | | | |
| 1.1 | Less production due to minimum tillage | | | | |
| 1.2 | Ever weed infestation due to minimum tillage | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 2 | Permanent crop residues | | | | |
| 2.1 | Crop residues cannot used as animal feed | | | | |
| 2.2 | Crop residues cannot used as fuel | | | | |
| 2.3 | lack or shortage of inputs for cover crops | | | | |
| 2.4 | free grazing problems | | | | |
| 3 | Crop rotation | | | | |
| 3.1 | Crop rotation is boring practices | | | | |
| 4 | knowledge gap of CA | | | | |

2.10. Institutional factors

2.10.1. Extension Services, Access to credit and inputs and Related Information

2.10.2. Have you ever received advice related to CA practices from extension officers before the project? 1= Yes [ ] 2= No [ ]

2.10.3. When you compare the last 1 year with previous years how do you evaluate the trend of extension contact?

a) Decrease…… b) Increase………. c) Remain the same ……….

2.10.4. Have you ever attended extension training since the introduction of CA?

A) Yes…. B) No…..

2.10.5. If yes how was the contribution of training in assisting you to adopt CA?

a) Good……. b) Satisfactory c) Poor………. d) I don't know

2.10.6. Are you sure with CA practices in reducing soil erosion and improving agricultural productivity? 1. Yes……. 2. No……. 3. If Yes how?

2.10.7. How long has the household been involved in farming activities? _________ yrs.

2.10.8. Does the household own a house? Yes [ ] =1 No [ ] =2

2.10.9. What type of housing 1= thatched 2. Iron roof 3. Iron roof and cemented

2.11. CA and its contribution to climate change Adaptation

2.11.1. Do you think CA contributed to climate change adaptation?

1. Yes 2. No

**Appendix 3 : Climate Risk**

Exposure and Sensitivity

| Climate risk in the past TEN (10) years | Please use tick √ mark | Occurrence of calamities in the past 10 years (Please use Tick √ on the appropriate box) | | | How severe the problems/shocks are (tick √as appropriate) | | | Did you get early warning (Yes/No) |
|---|---|---|---|---|---|---|---|---|
| | | Increasing | Decreasing | Same | High | Medium | Low | |
| Drought | | | | | | | | |
| Flood | | | | | | | | |
| Too much rainfall | | | | | | | | |
| Early rainfall | | | | | | | | |
| Late rainfall | | | | | | | | |
| Strong wind | | | | | | | | |
| Livestock disease | | | | | | | | |
| Crop disease | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Extreme heat | | | | | | | | |
| Others (specify) | | | | | | | | |

3.1. Over all contribution of Conservation Agriculture

Mention the benefits of the following CA practices in terms of production, climate change adaptation, soil fertility and soil and water conservation

3.2.1. Minimum Tillage

3.2.2. Permanent Crop Residue

3.2.3. Crop Rotation

| No | Benefits | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | Minimum Tillage | | | | | |
| 1.1 | Low labour requirement | | | | | |
| 1.2 | Simplified labour management | | | | | |
| 1.3 | Reduce production costs | | | | | |
| 2 | Permanent Crop Residue | | | | | |
| 2.1 | Avoiding reseeding of crops | | | | | |
| 2.2 | Reduce soil erosion | | | | | |
| 2.3 | Reduce fertilizer requirement | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | Crop Rotation | | | | | |
| 3.1 | Facilitate weed control | | | | | |
| 3..2 | Facilitate pest control | | | | | |

**Appendix 4 : The reasons often cited by people for not engaging in CA adoption (non-adopter)**

4.1.Please use a scale from 1 - 5 to rank the following reasons in order of importance to you (i.e., 1 = most important reason(s) and 5 = least important reason(s

| No | Reasons | Yes(1) or no(2) | Ranking |
|---|---|---|---|
| 1.1 | I don't have knowledge about CA management | | |
| 1.2 | I don't have the necessary labor to tend the CA | | |
| 1.3 | My land is too small to establish CA farm on it | | |
| 1.4 | My land is too productive to CA establishment | | |
| 1.5 | Conventional options offer better returns than CA practices | | |
| 1.6 | I supply the residue for livestock | | |

4.2. Do you intend to involve in CA in the future?

Yes [ ] =1 No [ ] =2 Don't know [ ] =3

4.3. If yes give reasons why you intend to practice CA in the future? ----------------

4.4. If no what factors would influence you to practice CA in the future? ------------

4.5. If you intend to establish CA farm in the future, indicate who or where you would obtain advice or information concerning CA development? -----------------------

**Appendix 5 : Checklist for Experts DA s Opinion on CA,**

5.1. Does the village/Kebele know about CA?

High [ ] Medium [ ] Low [ ] Very low [ ] Why?

5.2. What are the main economic activities in this village?

1. Farming 2. Petty trade

5.3. What is the trend of acceptance of CA since it has been introduced?

High [ ] Medium [ ] Low [ ] Very low [ ] Why?

5.4.What is the level of understanding of the community on CA?

High [ ] Medium [ ] Low [ ] Very low [ ] Why?

5.5.Do you know any problem facing village during implementation of CA?

5.6. What are the possible problems do farmers facing during the implementation of CA?

5.7.From three principles or pillars of CA which one is difficult to practice? Why?

Minimum tillage [ ] Crop rotation [ ] Cover crops [ ] Why?

5.8. What challenges do you expect to hinder the success of CA in your localities?

5.9.. What do you expect from Bureau of agriculture (from region to Woreda and FTC) to expansion of CA? From funding organization?

5.10. What is the performance of CA in your village?

5.11. What are the main benefits of that the farmers have obtained from the CA practices?

5.12. Do farmers adopting the practice?

**Appendix 6 : Guideline for Focus Group Discussion and Key Informants Interview**

**A. FGD**

1. What is the performance of conservation agriculture to climate change adaptation?

2 . What are the contributions of conservation of agriculture to climate change adaptation?

3. What are the factors affecting conservation of agriculture to climate change adaptation?

4. What are the constraints factors you face to adopt CA?

5. What is the major advantage you obtain/ lose as a result of integrating (not integrating) CA in farmlands?

6. What income difference you achieve after the adoption of the technology?

7. Do products you produce have a good market demand? Why?

8. What advantage do you gain, regarding marketing of products, from the proximity of the capital city?

9. How is the trend in the adoption of CA tree? Is it decreasing, increasing or no change? Why?

**B. Key informants interview**

1. What is the performance of Conservation agriculture practice in Gimbi pilot project?
2. What are the livelihood activities and conservation agriculture and its importance to the household economy of the local peoples? On-farm; off- farm; and, non-farm.
3. What is the income share of CA practices with respect to other off- and non-farm strategies, and why?

4. Why some people adopt CA practice and the other not?
5. What are the crops being cultivated in the Kebele?
6. What components are integrated in CA farms?
7. Do people intentionally plant trees in their farms? Yes or No
8. What types of crops are commonly planted?
9. What are the uses of these crops?
10. Do people use animal manure for CA? Yes No
11. Are farmers engaged in mixed cropping?
12. What are the problems encountered in CA farming?
13. Does the government provide any sort of support such as subsidies, or extension services? Yes No
14. If yes, mention which type of support ...........
15. What crops are considered food crops and which ones are commercial crops