COLLEGE OF DEVELOPMENT STUDIES

CENTER FOR REGIONAL AND LOCAL DEVELOPMENT STUDIES

THE DETERMINANTS OF CONSERVATION AGRICULTURE PRACTICE AMONG SMALL-HOLDER FARMERS: THE CASE OF GOZAMIN WOREDA, EAST GOJJAM ZONE, AMHARA REGION, ETHIOPIA

BY

BIMREW MOSSIE GELETA

JANUARY, 2021
ADDIS ABABA, ETHIOPIA

Addis Ababa University
College of Development Studies
Center of Regional and Local Development Studies

The Determinants of Conservation Agriculture Practice among Small-Holder Farmers: The Case of Gozamin Woreda, East Gojjam Zone, Amhara Region, Ethiopia

By Bimrew Mossie

A Thesis Submitted to the Center for Regional and Local Development Studies of Addis Ababa University in Partial Fulfillment of the Requirements for the Degree of Masters in Regional and Local Development Studies (RLDS)

Advisor: Dr. Kumela Gudeta

January, 2021

Addis Ababa, Ethiopia

Addis Ababa University

College of Development Studies

Center of Regional and Local Development Studies

Declaration

I, hereby declare that the thesis entitled “The Determinants of Conservation Agriculture among Small-Holder Farmers". This is my work and has not been submitted to any degree or diploma. All the sources of materials used for this thesis have been dully acknowledged.

Declared by:	Confirmed by Advisor:
Name: Bimrew Mossie	Name Kumela Gudeta (PhD)
Signature: ________________________	Signature________________
Date: _____________________________	Date_____________________

APPROVAL

This is to certify that the thesis prepared by Bimrew Mossie entitled: " The Determinants of Conservation Agriculture Practice among Small-Holder Farmers: The Case of Gozamin Woreda, East Gojjam Zone, Amhara Region, Ethiopia” and submitted in partial fulfillment of the requirement for the Degree of Master of Arts in Regional and Local Development Studies, complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

.

Approved by Board of Examiners:

Kumela Gudeta (PhD) Advisor Signature---------------_Date ------------

Aklilu Amesalu (PhD) Internal Examiner Signature---------------Date -------------

Meskerem Abi (PhD) External Examiner Signature--------------Date-------------

Chair of Department or Graduate Programs Coordinator

ACKNOWLEDGMENTS

First of all, I am very grateful to God for granting me courage, strength and health to finalize my study and success in this very important stage of my life. I would like to express my very great appreciation to Dr. Kumela Gudeta for his entire support during the whole work of the thesis. His, advice, corrections, valuable suggestions and devotion of his precious time throughout the whole processes. I have been learned a lot from his advice that significantly improved my professional capabilities. I could not have done it without his help from beginning to end. I would like to extend my sincere thanks to Dr. Akalu Firew for his valuable advice and encouragement. My sincere thanks to Mr. Basazinew Abate Gozamin Woreda MSCFSO local NGO project officer his contribution and cooperation during my field work. I am highly grateful thank Gozamin woreda Agricultural development Office staff, farmers and kebele extension workers for their cooperation in the field work. I would like to thank Mr. Yaregal Zelalem and Mr. Sied Melesse for their encouragements during my thesis work. Finally, very profound gratitude to my family for providing me with unfailing support and continuous encouragement.

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURES

LIST OF APPENDIX

ACRONYMS

ANRS	Amhara National Regional State
AGRA	Alliance for a Green Revolution in Africa
ATA	Agricultural Transformation Agency
CA	Conservation Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CRV	Crop Released Varieties
CSA	Climate Smart Agriculture
FAO	Food and Agricultural Organization
FH	Food for the Hungry
GDP	Gross Domestic Product
GM	Genetic Modification
GTP	Growth and Transformation Plan
GWADO	Gozamin Woreda Agricultural Development Office
IPCC	Intergovernmental Panel on Climate Change
Ha	Hectares
MSCFSO	Migbare Senay Children and Family Support Organization
NGOs	Non-Governmental Organizations
R&D	Research and Development
SHA	Self Help Africa
SSA	Sub Saharan Africa
TT	Traditional Tillage
2ACCA	Second Africa Congress on Conservation Agriculture
UNDESA	United Nations Department of Economic and Social Affairs
UNESCO	United Nations Educational Scientific and Cultural Organization
USA	United States of America

ABSTRACT

This paper examines the determinants of CA technology practice on major crop productivity among small holder farmers in Amhara region East Gojjam zone Gozamin woreda at (Yenebirina and Chimbord) kebele. The study was follow and employed mixed methods research approach addressed by cross- sectional survey data since the study has been done at one season of time and place. The results indicate that sampled households are found in different categories of crop productivity with CA technology practice, i.e., medium yield increment of crop productivity (11.58 %), high increment of crop productivity (65.26 %) and higher yield increment of crop productivity (23.16 %). The results of the ordered logit model show that some socio-economic and institutional factors affect the crop productivity under CA technology practice differently. Access to input, availability of mulch materials, age, level of education and percent of area of cultivated land covered under CA technology practice have significant positive influence on high and higher yield increment of major crop productivity category under CA technology practice.

The study shows CA extension advisory services is not included with multi discipline manner. There was limitation of integration of CA technology with farm implement mechanization. The study indicated that from the total cultivated land 38.58% covered under CA. Area of land coverage under CA is low due to constraints of mulch materials. The study result indicated among the three principles of CA technology practice (minimum soil disturbance, crop residue retention and crop rotations) farmers well practiced minimum soil disturbance and crop rotation. However, crop residues retention or mulching is not well addressed due to mulch material constraint.

Key-words

Conservation, agriculture, technology, tillage, rotation, mulch, major crop and productivity

CHAPTER ONE

INTRODUCTION

1.1 Background

Agriculture is a source of employment, income, food security and economic growth for more than 200 million people in Sub-Saharan Africa (ILO, 2017). In Ethiopia, agriculture accounts about 42 percent of the GDP, employs about 85 percent of the labor force contributes around 90 percent of the total export earnings of the country (Central Statistical Agency of Ethiopia, 2018). The sector is dominated by over 15 million small-holders producing about 95 percent of the national agricultural production (Central Statistical Agency of Ethiopia, 2018). This shows that the overall economy of the country and the food security of the majority of the population depend on small- holder agriculture.

Agriculture is a key sector of the Ethiopian economy. However, on account of climatic, social and institutional factors contributing to low production and productivity, unable to feed the population (Jirata, Grey, & Kilawe, 2016). Therefore addressing the adverse effects of climate change though climate smart agriculture practice and improving productivity is one of the major concerns of the country. Climate smart agriculture has to address simultaneously three intertwined challenges: ensuring food security through increased productivity and income, adapting to climate change and contributing to climate change mitigation (FAO, 2010a; Foresight, 2011a; Beddington, 2012a; Beddington, 2012b; HLPE, 2012a). Conservation Agriculture (CA) is one of the key climate smart agriculture activities, "CA offers climate change adaptation and mitigation solutions while improving food security through sustainable production intensification and enhanced productivity of resource use" (FAO 2010: 5). According to FAO, CA is an approach to managing agro- ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment. CA is characterized by three linked principles namely minimum soil disturbance, crop residue retention and crop rotation. .

Jirata, Grey, & Kilawe (2016) reported that introduction of CA in Ethiopia has been promoted through different NGOs, GOs and research institutions at different regions. CA initiated partners including FAO, ATA, the International Maize and Wheat Improvement Center

(CIMMYT), regional agriculture research center and a number of NGOs such as Ethiopia Wetland, FH Ethiopia, SHA, AGRA, Canadian Food Grains Bank and Wolayita Terepeza Development Association and Migbare Senay Family and children Support organization and among others.

Even though CA is a well-known method in many countries around the globe, it can be regarded as an innovation in Ethiopia (Jirata, Grey, & Kilawe. 2016). Similarly CA is as an innovation in Amhara region. The implementation of CA in Amhara region East Gojjam zone Gozamin woreda has been practiced by MSCFSO and woreda agriculture development office. The project's extension approach is a farmer-to-farmer one and uses government extension approaches to scale up the CA technologies. Thus this study examines opportunities, challenges and determinants of CA technology practice contribution for major crop productivity in Gozamin Woreda East Gojjam Zone Amhara Region.

1.2 Statement of the Problem

Agriculture in Ethiopia is characterized by excessive tillage, crop residue removal at harvest, overgrazing and biomass burning, which has led to land degradation, soil erosion and nutrient depletion (Michiel, 2001; Tesfay, 2015). Soil erosion is a severe problem in the highlands of Ethiopia, especially in Amhara Region (Selassie, Anemut, and Addisu,, 2015). Sheet, rill, and gully erosion are commonly observed in the high rainfall areas of East and West Gojjam zone where Nitisols are dominant (Yitaferu, 2003). Local people plowed the farmland many times to make the land more suitable for crop production through conventional tillage practices. However repeated tillage has been reported to be the main cause of land degradation in Ethiopia (Araya, 2012; Nyssen, 2011; Tumescent. 2008). Conservation Agriculture (CA) is important to reduce crop land degradation and increase land productivity (Araya, 2012). In addition, it is necessary to enhance the resilience of the production systems to biotic and abiotic stresses and shocks, particularly those arising from the impact of climate change on crop production (Kassam, Friedrich, & Derpsch, 2019).

Most of the farming system in Ethiopia mixed crop livestock farming system, similarly in the study area Gozamin woreda mixed crop livestock farming system. Retaining crop residues as surface mulch, together with minimum soil disturbance and crop rotation and association, forms the basis of conservation agriculture (CA,Kassam , 2009). Mixed crop-livestock African farmers generally feed the bulk of their crop residues to livestock and sacrifice on soil mulching i.e. they trade soil mulching for livestock feeding (Valbuena, 2012). When insufficient quantities of crop residues are retained as surface mulch, minimum tillage alone may lead to lower yields compared with the current farm practices, particularly on soils that are prone to crusting and compaction (Baudron , 2012).

Competition for crop residues between livestock feeding and soil mulching is a major cause of the low and slow adoption of conservation agriculture (CA) in sub-Saharan Africa (Baudron, Jaleta, Okitoi, & Tegegn, 2014). Several studies have quantified and explained crop residue trade-offs in mixed crop-livestock systems e.g. (Erenstein, 2002, 2003; Valbuena, 2012) but few have explored alternatives to feed both the livestock and the soil, and thus expand the niche in which CA would fit (Baudron, 2014).

Many of the existing studies examine in Africa individual components of CA application rather than the full package (Pannell, Llewellyn, & Corbeels, 2013). In Sub-Saharan Africa (SSA), a partially modified practice of CA is more common small-holder farmers tend to adopt only one or two of the three principles (Kunzekweguta, Rich, & Lyne, 2017).

Even though CA is practiced in the study area Gozamin woreda, it has limited application of full CA components. The full CA technology components practice were not yet transferred to the farming community. The need for such analysis is important to understand that the issues the determinant of CA technologies practice and farmer's perceptions and decision-making criteria for CA technology practice. The aforementioned gaps indicate that the application of association CA technology practice with crop residues as surface mulch, together with minimum soil disturbance and crop rotation practice still require thorough investigation. Thus, it is important to conduct a research to assess how the application of full CA component has been practiced. The general aim of this research is to analyze the drivers of CA technology practice and contribution for crop productivity through the application of CA technology practice.

1.3 Objective of the Research

1.3.1. General Objective

- To analyze the determinant of CA technology practice and contribution for crop productivity improvement.

1.3.2. Specific Objective

- To investigate the socio economic and institutional drivers of CA technology practice in Gozamin woreda
- To examine the contribution of CA technology practices on major crop productivity in Gozamin woreda
- To identify challenges and opportunities of CA technology practice among small holder farmers in Gozamin woreda

1.4 Significance of the Study

The finding of the study identifies the socio economic and institutional drivers of CA technology practice. In addition, the study identifies major challenges and opportunities for the CA technology practice among small holder farmers. The study would contribute and strengthening the existing CA technology practices in the study area. The findings of this study could be used for all concerned bodies working with agricultural sector including agricultural office, NGOs and policy makers. The study can be used for development planners engaged on conservation agriculture practice. Besides, the study may also serve as a point of reference for researchers who are intended to study in the area under investigation.

1.5 Scope of the Study

The study focused on analyzing drivers of CA technology practice and the contribution on major crop yield productivity. In this study the influence of CA technology practice on major crop productivity assessed from farmer's perspective through interview and field observation. The data was collected from sample respondents by using simple random sampling technique and cross-checked with sample analysis. Cross sectional research design surveys were used and assessed CA technology practice on major crop productivity. The study delimits in the selected Gozamin woreda with in Weyinadega agro ecological zone. Accordingly, any of the analysis, findings and result of the study represents Gozamin woreda having with Weyinadaega agro ecological zone alone.

1.6. Limitation of the study

The research data collection was done under the circumstance of COVID_19. The influence on focus groups and face-to-face interviews, the number of focused group discussion participants decreased (three to four members in one group) because of the limited number and physical/social distance. Due to the limitation of transport the research data collection had been taken more than 4 months. The result of the study may have limitations to make generalizations and make them applicable to overall country. However, it may be useful for areas with similar context with the study area.

1.7. Ethics

Before research work the study has been conducted consultation with stake holders doing with conservation agriculture. The main purpose of this consultation is to introduce the research objective to strengthening collaboration and to gather inputs from key stakeholders and discussed the state of conducting of research work in the selected rural Kebeles. The attendees of the consultation were East Gojjam zone agricultural office head, zone experts, Gozamin woreda office head, woreda experts, rural Kebele chairman and Kebele development agents and farmers. The survey objective and purpose of the study informed to the local people and individuals every action and movements have been done with knowing their culture, belief and according their volunteer. Besides, the enumerators live in the study area and they know well the environment, farmer's culture and norm and it would help and make smooth communication for the survey.

1.8. Organization of the Thesis

This thesis consists of five chapters. Chapter one deals with the background, problem statement, objectives, scope, limitation, and significance of the study. Chapter two reviews related literature appropriate for the research topic. Chapter three deals with research methodology including description of the study area, research approach, sample frame and sampling techniques, method of data collection and analysis. Chapter fourth presents and discusses the results of the study. Chapter five includes conclusion and recommendations

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Definition and Concepts

2.1.1. Conservation Agriculture

Kassam , (2009) defined CA by a set of principles which can be applied essentially to all crop production systems and that these CA-based principles can provide the foundation to support most crop management/ improvement activities. These CA principles are applicable to a wide range of crop production systems from low yielding, dry, rain fed conditions to high-yielding, irrigated conditions. However, techniques to apply the principles of CA will be very different in different situations, and will vary with biophysical and system management conditions and farmer circumstances (Sayre & Govaerts, 2006). Specific and compatible management components (pest and weed control tactics, nutrient management strategies, rotation crops, appropriately-scaled implements etc.) will need to be identified through adaptive research with active farmer involvement (Sayre & Govaerts, 2006).

FAO defines Conservation Agriculture as an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment. CA is characterized by the practical application of three linked principles, along with other complementary good agricultural practices of crop and production management (Kassam, 2019).

Principles of Conservation Agriculture

Principle 1: Continuous no or minimal mechanical soil disturbance (implemented by the practice of no-till seeding or broadcasting of crop seeds, and direct placing of Planting material into untilled soil; no-till weeding and causing minimum soil disturbance from any cultural operation, harvest operation or farm traffic).

Principle 2: Maintenance of a minimum 30% permanent biomass soil mulch cover on the ground surface (implemented by retaining crop biomass, root stocks and stubbles and cover crops and other sources of ex-situ biomass) and

Principle 3: Diversification of crop species (implemented by adopting a cropping system with crops in rotations, and/or sequences and/ or associations involving annuals and perennial crops, including a balanced mix of legume and non-legume crops).

2.1.2. Technology Adoption

Various authors define technology in different ways. (Loevinsohn, 2013) define technology as a means and methods of producing goods and services, including methods of organization as well as physical technique. According to these authors new technology is new to a particular place or group of farmers, or represents a new use of technology that is already in use within a particular place or amongst a group of farmers. Technology is the knowledge/ information that permits some tasks to be accomplished more easily, some service to be rendered or the manufacture of a product (Lavison 2013). Technology itself is aimed at improving a given situation or changing the status quo to a more desirable level. It assists the applicant to do work easier than he would have in the absence of the technology hence it helps save time and labor (Bonabana-Wabbi 2002). Technology can be described as the integration of people, knowledge, tools and systems with the objective to improve people's lives (Porter, 1985). According to Betz (1998), technology is always the means of creating new tools serving humans and their environment.

Adoption on the other hand is also defined in different ways by various authors. (Loevinsohn, 2013) defines adoption as the integration of a new technology into existing practice and is usually proceeded by a period of 'trying' and some degree of adaptation. Citing the work of Feder, Just and Zilberman (1985), Bonabana-Wabbi, (2002), defines adoption as a mental process an individual passes from first hearing about an innovation to final utilization of it. Adoption is in two categories; rate of adoption and intensity of adoption. The former is the relative speed with which farmers adopt an innovation, has as one of its pillars, the element of 'time'. On the other hand, intensity of adoption refers to the level of use of a given technology in any time period (Bonabana-Wabbi 2002). Technology adoption refers to a decision to make full application of an innovation as the best course of action (Rogers, 2003).

2.1.3. Sustainable Agricultural Development

Sustainable agriculture is an agricultural practice that seeks to make use of nature's goods and ecosystem services, while producing an optimal yield in an economically, environmentally, and socially rewarding way, preserving resources for future generations (Koohafkan, Altieri, &

Initiative, 2011). Sustainable agricultural development is agricultural development that contributes to improving resource efficiency, strengthening resilience and securing social equity/responsibility of agriculture and food systems in order to ensure food security and nutrition for all, now and in the future. “Sustainability, therefore, is much more than ensuring protection of the natural resource base. To be sustainable, agriculture must meet the needs of present and future generations for its products and services, while ensuring profitability, environmental health, and social and economic equity. Sustainable agriculture would contribute to all four pillars of food security availability, access, utilization and stability in a manner that is environmentally, economically and socially responsible over time.” (FAO, 1988; 2014a, p. 12)

2.1.4. Agricultural Transformation

The agricultural transformation agenda is a set of interventions that unlock systemic bottlenecks within the agricultural sector to catalyze transformation from a subsistence oriented, low output agricultural sector to a high performing sector well integrated into the national economy and to do so in an environmentally sustainable and inclusive manner (EATA, 2015).

Agricultural transformation is multi-sectorial, because it requires the development of entire value chains and market systems that can provide strong livelihoods, often to most of a country’s population (Said, 2018). Agricultural transformation can be described as “the process by which an Agrifood system transforms over time from being subsistence-oriented and farm centered into one that is more commercialized, productive, and off-farm centered.” (AGRA, 2016).Successful transformations are business-led, and involve the creation of three simultaneous conditions: 1. a large- scale dissemination of productivity-increasing technology and inputs, plus input intensity and capital intensity; 2. the development of input and output market structures and incentives that allow the full realization of the value of increased production; and, 3. a well-functioning and vibrant private sector that can manage and allocate skill and capital to scale emergent success and drive long-term sustainable agribusiness growth (Feed Africa, 2016).

Barrett et al. (2017) focuses more on the efficiency of agricultural sector from abrader perspective. They view the transformation essentially as process where by the agriculture become more efficient productive. On the other hand, Ba et al. (1999, p.1) defined agricultural transformation as a process in which (1) agriculture becomes increasingly reliant on input and output markets, (2) it integrates more fully with other sectors of the economy, and (3) local producers in the food system increasingly incorporate modern scientific knowledge in to their practices. The first and the second aspect imply greater an exposure of agricultural sector not only to the non-agricultural sector of the country but also the rest of the world (Imai, 2017). Climate-smart agriculture can helps transform the agriculture sector and increase food security. Climate-smart agriculture is concerned with moving the agriculture sector forward in order to achieve sustainable development (economic, social and environmental), while at the same time addressing food security and climate challenges. It is built on three main pillars (FAO 2013): 1. Sustainably increasing agricultural productivity and incomes; 2. Adapting and building resilience to climate change; 3. Reducing and/or removing greenhouse gases emissions (GHGs), where possible.

2.2 Literature Review

2.2.1. History of Conservation Agriculture

CA as a method, and its various principles, has been practiced long before people started to talk about climate-smart agriculture (McCarthy, Lipper, and Branca,, 2011). CA began in the United States of America (USA) in the 1950s among commercial farmers (Kassam, Ward et al., 2018). Three key factors were responsible for the emergence of CA in the US, namely: (1) the need to protect farmers against severe wind erosion through dust storms caused by conventional ploughing during a prolonged drought period in 1930s (also referred to as the 'US dustbowl) (Brown ., 2018, DeClerck, Gatere, & Grace, 2014); (2) the discovery of herbicides in the 1940 and 1950 (Brown, 2018; Lal, 2009; Palm, 2014); and (3) the need to curb rising costs of fuel and labor in crop production (Brown, 2018). Over time, the popularity of CA in the US grew due to increased viability of crop farming as an enterprise, availability of low-cost inputs and equipment, farmer involvement in co- innovation, and the USA government's adoption of policies that promoted CA (Brown, 2018). From the US, CA spread to South America, particularly Brazil, among large-scale farmers, and later to small-scale farmers in the 1990s (Baudron, Corbeels, Monicat, & Giller, 2009; Brown, 2018). Currently, efforts have focused on expanding CA among smallholder farmers in SSA and South Asia (Palm, 2014; Pittelkow, 2015).

Conservation agriculture (CA) is defined by the Food and Agriculture Organization (FAO) as a crop farming practice characterized by simultaneous implementation of the three principles of minimal tillage and soil disturbance; minimum 30% permanent soil cover using crop residue and mulches; and crop rotation and intercropping with three or more types of crops (Llewellyn, & Nuberg, 2018). In sub- Saharan Africa (SSA), partially modified practice of CA is more common. Smallholder farmers tend to adopt only one or two of the three principles (Kunzekweguta, Rich, & Lyne, 2017). Some of the factors that affect the adoption and practice of CA by farmers include costs related to transitioning from conventional agriculture; ability to effect change; perceived change benefits; and prevailing institutional and biophysical environment (,Kunzekweguta 2017). Currently, only 0.3% of farmers in Africa practice CA in ways that meet the FAO specifications and only 0.8%, if the CA principles are applied in any combination and intensity (Brown , 2018). Overall, the practices of CA is much less common in SSA compared to the US, Mexico, Australia, and Southeast Asia (Pittelkow , 2015; Ward, Bell, Droppelmann, & Benton, 2018).

CA as a systems are now existence in all continents in all land-based agriculture, supporting the notion that CA principles are universally applicable to all agricultural landscapes and land uses with locally formulated and adapted practices. According to (González-Sánchez et al., 2018) their presence extends from the equatorial tropics (e.g., Kenya, Tanzania, Uganda) to the arctic circle (e.g., Finland) North and to about 50º latitude South (e.g., Falkland Islands); from sea level in several countries of the world to 3,000 m altitude (e.g., Bolivia, Colombia); from heavy rainfall areas with 2,000 mm a year (e.g., Brazil) or 3,000 mm a year (e.g., Chile) to extremely dry conditions in the Mediterranean environments with 250 mm or less a year (e.g., Morocco, Syria, Western Australia).

African farmers developed conservation systems many centuries ago as it was the most natural way of agriculture. With the arrival of colonialism coming from occident and the introduction of the plough these conservation practices were stopped (Fowler, 2000). Since the mid-1990s, FAO in association with non-governmental organizations, national governments and various research and development institutions, promoted the introduction of CA for agricultural development and the livelihoods of small farmers in Africa (Giller, Witter, Corbeels, & Tittonell, 2009). CA is spreading in eastern and southern Africa, and North Africa using indigenous and scientific knowledge, and equipment design from Latin America (Kassam, 2019). There have been numerous efforts at some sort of conservation farming or sustainable farming practices. These range from practices directed and enforced by government legislation to agronomic recommendations developed and promoted by and through government and NGOs agricultural extension services (González-Sánchez, 2018). Conservation Agriculture has been shown to be relevant and appropriate for small and large scale farmers at all levels of farm power and mechanization, from manually operated hand tools to equipment drawn by animals to operations performed by heavy machinery. However, despite the inherent benefits of CA, this form of agriculture is scarcely adopted in Africa in relation to other parts of the world.

Kassam and Mkomwa (2017) indicated the slow spread adoption of CA in Africa as compared to other continents: (i) continued promotion and development support of tillage-based agricultural systems by national and international, public and private institutions; (ii) weak policies and regulatory frameworks and institutional arrangements to support the promotion and mainstreaming of CA; (iii) inadequate awareness, knowledge and expertise of CA systems and the process of their adoption and spread among policymakers, academic, research, extension and technical staff;

(iv) inappropriate CA technology packaging and dissemination; (v) inadequate CA based enterprise diversification and integration in farming systems; (vi) inability of smallholders to diversify crop rotations, sequences and combinations; (vii) inadequate skills and competencies among farmers and other CA practitioners; (viii) farmers' inability to maintain year-round soil cover through the use of specially introduced cover crops, intercrops and crop residue; (ix) poor availability and access to the required CA equipment, machinery and inputs; and (x) absence of a strong continental body and strategic policy framework to guide the promotion and mainstreaming of CA across Africa. However, are noticed to require further improvement: accessibility of markets for CA products and inputs; adaptation of machinery and seeds to the CA practices; introduction of quality implementation measures; and a renewed motivation (interest) among CA service providers (Ndah, 2015).

Conservation agriculture is one of the key CSA activities conducted in Ethiopia from 1998 onwards. Since then, numerous trials and development work on conservation agriculture have been undertaken. Ethiopia lacks knowledge and skills pertaining to CSA and conservation agriculture in particular (Jirata, Grey, & Kilawe. 2016). CA has been promoted by different organizations including Sasakawa Global (SG2000), FAO, the Agricultural Transformation Agency (ATA), the International Maize and Wheat Improvement Center (CIMMYT) and a number of NGOs such as Ethiopia Wetland, FH Ethiopia, Self Help Africa, and AGRA, Canadian Food grains Bank and Wolayita Terepeza Development Association, among others (Jirata, Grey, & Kilawe. 2016). In 2010 FAO, in collaboration with the Federal and Regional Agricultural Offices, provided technical and financial support for conservation agriculture promotion in Ethiopia. In general, however, adequate data on the adoption of conservation agriculture in Ethiopia are not well documented and available at all levels (Jirata, Grey, & Kilawe. 2016).

2.2.2. Drivers of conservation Agriculture

2.2.2.1. Climate Smart Institutions

Institutions factor is the most critical success element in agriculture (Robinson and Acemoglu 2012). Institutional innovation in scaling refers to institutional change and institutional design. It therefore begins from change in context, and includes networking development, institutional arrangements, and change in existing institutional capacity for transformation of agricultural scaling. Scaling is a critical element in agricultural sustainable intensification (IIRR 1998; Uvin and Miller 1994; Proctor 2003). It requires significant structural drivers, especially related to institutional innovation, given the ever-evolving contexts.

Lipper and Zilberman (2018), argues that a major push of CSA is the improvement of climate change and agricultural governance through better coordination and institutional strengthening. Institutional environments by themselves have a significant impact on farmer's incentives and ability to invest in agriculture practices and to adapt to climate change (McCarthy, 2018).

Adaptation capacity of agriculture hence smallholder farmers to climate change begin with investments in and incentives for innovation. Public investments in infrastructure such as rural roads, market places, storage facilities and related services will be essential in reducing transactions costs faced by poor households. Developing such infrastructure and supply chains requires strong involvement of the private sector, sometimes in partnership with the public sector, within an improved policy environment (Zilberman, 2018).

Private and public sector partnerships in this sense will be important in providing some of these investments and also in expanding and improving the supply chains of credit and farm-level inputs and outputs. Institutions related to knowledge and research is also key elements in enabling CSA. These are responsible for making the right technologies and information to farmers as well as the know-how in the use of these technologies. In this regards, a bottom-up approach has been suggested as highly relevant to streamline information flow from farmers to researchers and vice versa. Factors also pertaining to conducive enabling policy environments and public investment, assurance of peace and security, stable macro-economic conditions, functioning markets and appropriate incentives can act as an important stimuli in making agriculture climate smart (Ehui and Pender, 2005; Westermann, 2015).

2.2.2.2. Dynamic Institutional Capacity to Support CA

CA is not a static set of technologies, but a dynamic system that differs from place to place and from year to year, depending on the prevailing bio-physical and socio-economic conditions facing individual farmers. The institutions that are set up to promote and support CA need to be similarly dynamic so that they can respond to farmers' varied and changing needs (Agriculture, 2009). As well as policymaking departments (see above), these institutions include the research and development programmes on which much of the technical knowledge of CA is based. Whatever technological combinations are used by farmers, R&D activities must help to assure that good husbandry of crops, land and livestock (Shaxson, 2006) can occur simultaneously for the system to function well.

Both the technical and social sciences must be combined with the views and opinions of stakeholders to develop technologies and systems that can be adapted to varied conditions facing farm families adopting CA as a way of farming. This means that the diverse providers of information – and their investors – need to be involved in broad programmes to develop the science and technology for CA. Such institutions include international agencies, multi-donor programmes, NGOs, national government staff, academic institutions, commercial organizations and agribusiness (Agriculture, 2009). Each brings a different expertise and understanding to the table. However, unless these are tied together within a common framework of understanding of the principles and benefits of CA, their potential synergy cannot be felt. One way forward would be to develop common indicator sets to assess progress towards the environmental, economic and social benefits of CA. This would help promote CA as the sustainable alternative to tillage-based agriculture techniques, and to build a common basis for understanding the potential of CA for both large and small-scale farming communities (Agriculture, 2009).

2.2.2.3. Engaging With Farmers

Support for any production systems should be oriented towards solving farmers' problems that inhibit productivity. Farmers need support to understand new concepts and principles, enable an intellectual change in mind-set, commit to a longer-term process of change in their production system, test and adapt new practices, and change equipment and machinery (Kourilsky, 2009). In establishing different cropping systems and farm operations, they also need to manage new production input and output relationships involving crop, soil, and nutrient, water, pest, and energy management practices. Though the principles of CA remain the same across contexts, how they can be best applied depends on how individual farm families make decisions. This emerges from how each farm family can respond to specific combinations of environmental conditions, farmers' resource-availability, production system, market opportunities and transport availability, and support, encouragement and guidance (Wall, 2007). Farmers can be ingenious in problem-solving, and if they pick up the conceptual part of CA, they often innovate and adapt the practices to their own conditions (WOCAT, 2007; Borsy et al., 2013).

2.2.2.4. The Importance of Farmers Organizations

Farmers tend to believe trusted peers more than their formal advisers when discussing innovations, making it easy for them to exchange ideas and experiences helps strengthen their own linkages and reinforce recommendations (Pretty, 2003).

Social capital is used as a term to describe the importance of social relationships in cultural and economic life. Social capital is thus seen as an important pre-requisite to the adoption of sustainable behaviors and technologies over large areas (Cernea & Kassam, 2006). Where social capital is high in formalized groups, people have the confidence to invest in collective activities, knowing that others will do so too.

Farmers participation in technology development and extension approaches has emerged as a response to such new thinking (Pretty, 2011). Farmer groups, which may comprise associations, clubs, co-operatives or other organizational arrangements, derive confidence from mutual support and exchange, which can accelerates innovation and adoption e.g (Silici ., 2011; Marongwe *et al.*, 2011). The fastest development of suitable technologies is usually achieved through groups of innovative and pioneer farmers who are part of a community and exchange their experiences through their networks, thus building social capital (Pretty, 2003).

Small informal groups of farmers may evolve into co-operatives and other larger bodies. If such bodies already exist, they may embrace the CA ethic and actions, and draw in new members. Such groups and organizations also develop bargaining power with buyers and sellers, traders, equipment related service providers, transport agencies, and others: and this benefits all the members of the group (Pretty, 2014). If sufficiently well organized, they may be able effectively to pressure national and local governments and institutions for necessary reforms and services, including research and extension, to aid the CA cause (Pretty, 2014).

2.2.2.5. Access to Information and Extension Services

Access to extension services has also been found to be a key aspect in technology adoption. Farmers are usually informed about the existence as well as the effective use and benefit of new technology through extension agents. Extension agent acts as a link between the innovators (Researchers) of the technology and users of that technology. This helps to reduce transaction cost incurred when passing the information on the new technology to a large heterogeneous population of farmers (Genius, 2010). Extension agents usually target specific farmers who are recognized as peers (farmers with whom a particular farmer interacts) exerting a direct or indirect influence on the whole population of farmers in their respective areas (Genius, 2010).

2.2.2.6. Access to Credit and Input for CA

CA can be used with many types of production inputs, including seeds of traditional or modern cultivars, at any level of agricultural development and farm power, manual, animal assisted or mechanized. This flexibility allows CA to target inputs (e.g. fertilizers, seeds, equipment) and using them regardless of the source which may be organic or mineral in the case of fertilizers, and GM or non-GM in the case of seeds (Kourilsky, 2009). With farmers grouping together into associations, potential suppliers of inputs and technical advice will become aware of potential commercial opportunities, and can be encouraged to join, and provide supplies to the farmers themselves. In the short to medium term, policy makers could support activities of national and regional CA working groups to ensure that relevant thematic (research, technical, extension, training, education, input and output markets, policy) areas are covered by various CA programmes. CA could be integrated into interventions such as seed, fertilizer and tillage and draft power support programmes as a way of further enhancing productivity (Bhan & Behera, 2014).

Important thing for successful adoption of CA is the need to provide credit to farmers to buy the equipment, machinery, and inputs through banks and credit agencies at reasonable interest rates. At the same time government need to provide a subsidy for the purchase of such equipment by farmers (Bhan & Behera, 2014). For example, the Chinese government in recent years adopted a series of policy and economic measures to push CA techniques in the Yellow River Basin and is providing a subsidy on CA machinery and imparting effective training to farmers (Yan, 2009). This resulted in a considerable increase in area under CA. Currently in Shanxi, Shandong and Henan provinces over 80% area under maize cultivation depends on no till seeder.

2.2.2.7. Gender Mainstreaming In Conservation Agriculture

Gender dynamics affect and are affected by agricultural tasks, practices, functions and roles, and shape relationships and outcomes in the context of farming. Gender remains one of the most important social institutions and factors in African development (Hachiboola, 2016). Learning can be generated from an understanding of CA as a site for gendered outcomes. More importantly, the varying social, economic, and environmental impacts of CA in relation to gender need to be understood (Farnworth, 2016).

Solutions developed to support women farmers will need to take into account access to resources, assets and decision-making at the household level. Because of the different work that men and women do, which is largely dictated by gender norms, men and women perceive climate change differently and are affected by it in different ways. Strategies for implementation need to be developed in consultation and continuous assessment with women smallholders (Jost, 2015; Duong et al., 2016). Many conservation agriculture approaches have failed to achieve nutrition goals and in fact have increased women's workloads, for example, emphasis on manual weeding depends on women's labour in many areas, and as a result, these practices may not be adopted by women (Beuchelt and Badstue, 2013). Women face several challenges in relation to CA. Available evidence shows that overall, women's limited decision-making power affected their involvement in CA. Women are generally not involved in household level decision-making related to CA in SSA (Farnworth, 2016).

In Ethiopia, the adoption of a package of sustainable agricultural practices (SAPs) of which CA was part of increased women's workload a clear indication that 'agricultural intensification technology interventions may not be gender neutral' (Teklewold, Kassie, Shiferaw, & Köhlin, 2013; Wekesah et al., 2019). The Ethiopian government gave attentions for gender mainstreaming. And among the Ethiopian pillar strategies of GTP-II (FDRE, 2019) are increase the productive capacity and efficiency improving quality, productivity and competitiveness of productive sectors (agriculture and manufacturing industries); Promote women and youth empowerment, ensure their participation in the development process and enable them equitably benefit from the outcomes of development; Build climate resilient green economy.

2.2.2.8. Mechanization and Equipment for Conservation Agriculture

CA is bound to fail if suitable equipment is not available to drill seed into residues at the proper depth for good germination. It is urgent that CA equipment is perfected, available and adopted for this new farming system. The main requirements of equipment in a CA system are a way to handle loose straw (cutting or moving aside), seed and fertilizer placement, furrow closing and seed/soil compaction (Hobbs, Sayre, & Gupta, 2008). There is also a need for small-scale farmers to adapt direct drill seeding equipment to manual, animal or small tractor power sources (reduced weight and draft requirements) and reduce costs, so equipment is affordable by farmers, although use of rental and service providers allows small-scale farmers to use this system even if they do not own a tractor or a seeder (Hobbs, 2008).

A simple three-row small grain seeder has been developed for small-scale animal- powered farmers in Bolivia (Wall et al. 2003). This equipment uses a shovel rather than a disc opener to save weight. It has straw wheels attached to the coulter to help move residues aside and reduce clogging. It also has the benefit that it can be used in ploughed or unplugged soil. The main benefit farmers mentioned about this drill was savings in time; it takes 10 hours to plant a hectare with this machinery and 12 days for the TT and seeding method. Similar information was provided by (Ribeiro (2003) for planters in Brazil. These can be manually applied jabber planters to animal-drawn planters. In both countries, the participation of farmers, local manufacturers and extensions was vital for success. Conventional tillage practices involve challenges in preparing the soil in time for the critical, limited sowing and planting period given unpredictable rains and requirements for repeated plowing. Conservation tillage involves minimizing land degradation resulting from soil disturbance no tillage is one method and low tillage is another (Bruce, 2013).

In the short term, consideration could be made on removing or reducing tariffs on imported CA equipment and implements to encourage and promote their availability. In the medium to long run, local manufacture of these will increase availability, ensure that equipment is adapted to local conditions, increase employment opportunities and reduce costs (Bhan & Behera, 2014).

In Ethiopia Traditional land preparation with the maresha plough creates V-shaped furrows with unplowed strips of land between them, requiring extensive repeated plowing and cross-plowing to prepare an appropriate seed bed (particularly for crops like teff that require a very fine seed bed) (Temesgen, 2015). Clods form as soil is pushed with blunt wooden wings, further necessitating repeated plowing. Extensive time is spent re-plowing already plowed soil. High draft power is required to prepare a fine seedbed (Temesgen, 2015). Melesse's PLC is produce affordable, reliable and easy-to-adopt equipment Silet Deger (also known as berken maresha) that are helpful in improving agricultural work, by facilitating the practice of conservation agriculture (Temesgen, 2015). This tool decreases loss of carbon, nitrogen, water and other nutrients from the soil by reducing the number of times a field must be plowed and cross-plowed. This deger makes a U-shaped furrow which is good for water infiltration and root growth, whereas the traditional maresha makes a v shape so there is high runoff and the soil is opened up for more evaporation, erosion and loss of nutrients such as organic carbon (Temesgen, 2015).

2.2.2.9. CA and Crop Productivity in SSA Countries

Crop yields are generally higher under CA, at least in the long run (Friedrich, 2017; Johansen , 2012; Knowler & Bradshaw, 2007; Lalani, 2017; Pannell, 2014). Studies from farmers' field experiments and farm surveys show higher yields under CA across diverse agro-ecologies for a variety of crops in Sub-Saharan Africa, including Ethiopia (Araya, 2011; Zerihunet , 2014), Malawi (Ngwiraet, 2012; Nyagumbo, 2016), Western Africa (Bayala, 2012) and Zambia,

(Abdulai, 2016). Using farm survey data, Lalani et al. (2017) find that benefits could also extend to the poorest group of farmers for a variety of crop mixes and risk levels. However, increased yields are not always guaranteed under CA. Yield benefits often depend on a variety of factors and the combined implementation of different practices (Nyamangara, 2014; Thierfelderet , 2015; Zheng, 2014). Yield increases are often realized when CA is practiced for several years (Rusinamhodzi, 2011) because it takes time for soil quality to improve and farmers to gain experience implementing CA. Moreover, successful CA adoption in developing countries is usually accompanied by the addition and correct management of external inputs such as fertilizers, pesticides, herbicides and improved seed varieties (Giller, 2009), as well as the investment in special machinery and skills (Johansen, 2012).

2.2.2.10. Labor Requirement of CA

CA alters how agriculture is carried out, potentially changing the amount of labour required across different production stages (e.g. land preparation, weed control, harvesting and threshing). In minimizing tillage, the amount of labour required in the early stages of the growing season (e.g. land preparation) may be lower (Baker & Saxton, 2007; FAO, 2001), but may increase labor requirements in the following stages (e.g. weed control if the same herbicides are used) (Erenstein, 2002; Pannell, 2014). In producing higher yields, CA may also increase the labour required in the harvesting and threshing stages (Farnworth , 2016).

Little attention has been given to how CA impacts the requirement and distribution of labour in Sub- Saharan Africa. Teklewold et al. (2013). According to the report of (ILO, 2018), CA's labor outcomes in Ethiopia by considering the three components of CA and the adoption of improved seed varieties. The study evaluates the impacts of conservation tillage (which refers to either reduced tillage or zero tillage combined with residue retention), improved maize variety and crop diversification on households income, agrochemical use and demand for labor. They find that minimum tillage adopted in isolation actually increased labor demand when compared to conventional agriculture, but the impact on labor demand became statistically insignificant when minimum tillage is combined with crop diversification. Indeed, the specific availability of machinery, chemical inputs and skills in Sub-Saharan Africa may result in CA having different effects on labor requirements than those observed in other regions or in experimental studies observed in other regions or in experimental studies.

2.2.3. Challenges and Opportunities for the Adoption of CA at Small -Holder Farmers

2.2.3.1. Challenges

Farmers in a country or region, where CA is not practiced, face a number of problems which make adoption difficult. These problems are of diverse nature, such as intellectual, social, biophysical and technical, financial, infrastructural and policy. Most farmers are facing, several of these problems, if not all, at the same time to the effect that only very few bold pioneer farmers adopt CA (Tekle, 2016).

Mindset of the Plough

The plough has been part of the very early developments of agriculture and has the character of a brand symbol for what is 'correct'. It is therefore difficult for people to accept that all of a sudden the plough is dangerous and that a crop can grow without tilling the land (Tekle, 2016).

A mental change of farmers, technicians, development agents and researchers away from soil degrading tillage operations towards sustainable production systems like no tillage is necessary to obtain changes in attitudes of farmers (Derpsch, 2001). Hobbs and Govaerts (2010) however, noted that probably the most important factor in the adoption of CA is overcoming the bias or mindset about tillage. Yet, there are no systematic analyses and the literature seems equivocal about this adoption barrier, as it is also suggested that, unlike researchers and extension workers, 'Farmers generally undergo this change in mindset relatively quickly when they experience, or are exposed to, the benefits of CA' (Wall, 2007, p. 142). CA is now, considered a route to sustainable agriculture. Spread of conservation agriculture, therefore, will call for scientific research linked with development efforts (Bhan & Behera, 2014).

Shortage of Availability of Crop Residues or Other Mulch

Communal grazing rights, which often include the right to graze on crop residues or cover crops after the harvest of the main crop, create conflicts which make it difficult for the uptake of CA practices (Tekle, 2016). These problems can be real impediments to the adoption of CA and conflicts arising, for example, from alternative uses of crop residues as mulch or animal feed cannot be solved by orders or directives. Besides, crop residue is not only used as a livestock feed, but also as a fuel wood for cooking purposes. If crop yields are very low (i.e. areas of less than 500 mm rainfall in Africa), there may be insufficient quantity of residues to effectively practice CA.

Limited Application of Full CA Principles and Components

In Africa in many cases, especially smallholders often adopt only one or two of CA's three interlinked components, thus failing to establish CA systems and harness the full benefits of CA (Mazvimavi & Twomlow, 2009; Pannell, 2014; Ng'ombe, 2017). In sub-Saharan Africa

(SSA), a partially modified practice of CA is more common. Smallholder farmers tend to adopt only one or two of the three principles (Kunzekweguta, Rich, & Lyne, 2017). Some of the factors that affect the adoption and practice of CA by farmers include costs related to transitioning from conventional agriculture; ability to effect change; perceived change benefits; and prevailing institutional and biophysical environment (Brown, Nuberg, & Llewellyn 2017b; Kunzekweguta, 2017).

Long-Term Research Perspective

Conservation agriculture practices, e.g. no-tillage and surface maintained crop residues result in resource improvement only gradually, and benefits come about only with time. Indeed in many situations, benefits in terms of yield increase may not come in the early years of evaluating the impact of conservation agriculture practices (Bhan & Behera, 2014). Understanding the dynamics of changes and interactions among physical, chemical and biological processes is basic to developing improved soil-water and nutrient management strategies (Abrol and Sangar, 2006). Therefore, research in conservation agriculture must have longer term perspectives.

Building a System and Farming System Perspective

A system perspective is built working in partnership with farmers. A core group of scientists, farmers, extension workers and other stakeholders working in partnership mode will therefore be critical in developing and promoting new technologies. This is somewhat different than in conventional agricultural R&D, the system is to set research priorities and allocate resources within a framework, and little attention is given to build relationships and seek linkages with partners working in complementary fields (Bhan & Behera, 2014).

Lack of Access to Credit and Input

Access to equipment, seeds, fertilizers, and herbicides is a significant constraint to scaling up CA in Africa. CA does not necessarily require more equipment than conventional agriculture, but some of the equipment is different and is not always available (Tekle, 2016). The other important thing for successful adoption of CA is the need to provide credit to farmers to buy the equipment, machinery, and inputs through banks and credit agencies at reasonable interest rates (Bhan & Behera, 2014). However in developing countries including Ethiopia limited financial and credit s services had been observed.

Although the profitability of CA is usually higher than for conventional farming practice there are still financial hurdles to adoption, depending of the availability of capital to invest into this change of production system. Changing a production system to CA is a long term investment. In many cases the rationale for the change is the degradation of the natural resources, especially of soil and water, as a result of the previous tillage-based agriculture. In order to start with CA and to successfully create favorable conditions for the soil life and health to return, some initial investment into the land might be necessary, such as breaking existing compactions by ripping, correction of soil pH or extreme nutrient deficiencies, leveling and shaping of the soil surface for the cropping system foreseen under CA. Especially for small subsistence farmers the capital for this kind of investment is not available. In addition to this, the farmer needs new equipment, while most of the existing equipment is becoming obsolete and will most likely not find an attractive second hand market (Tekle, 2016).

Lack of availability of required inputs and equipment such as non-selective glyphosate-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 (Jirata, Grey, & Kilawe. 2016).

Delayed Yield Benefits

CA is generally more profitable in the long-term than conventional farming. However, achieving these long-term benefits may require initial investment In addition, while many farmers reap benefits in the first year of practicing CA, others do not realize increased yields or profitability for 3-7 years (Hobbs, 2007). During this time, farmers sometimes choose to abandon CA; thus, long-term adoption is more likely when CA provides significant benefits in the first or second year Such immediate benefit is more likely when CA is promoted in conjunction with good agronomic practices, improved seeds, and sometimes inorganic fertilizers (Tekle, 2016).

Biophysical and Technical Constraints to Adoption

Although the concept of CA is universally applicable, this does not mean that the techniques and practices for every condition are readily available. In most cases the actual CA practice has to be developed locally, depending on the specific farming situation and agro-ecological conditions (Tekle, 2016). Especially the crop rotations, selections of cover crops, issues of integration of crop and livestock have to be discovered and decided upon by the farmers in each location. A diversity of problems arises, very often around weed management, residue management, equipment handling and settings, planting parameters like timing and depth, which all have to be discovered new. This creates the problem that extension agents and advisors in the beginning, when CA is newly introduced in a region, cannot give specific advice on practices, but have to develop these practices together with the farmers (Tekle, 2016). On the other side such an approach, if correctly applied, is much quicker and more sustainable than the development of specific practices by scientists, since it uses the immense pool of experience and innovation potential of the farmers' community.

Policy Constraints to Adoption

Adoption of CA can take place spontaneously, but it usually takes a very long time until it reaches significant levels. Adequate policies can shorten the adoption process considerably, mainly by removing the constraints mentioned previously. This can be through information and training campaigns, suitable legislations and regulatory frameworks, research and development, incentive and credit program. However, in most cases policy makers are also not aware about CA and many of the actually existing policies work against the adoption of CA. Typical examples are commodity related subsidies, which reduce the incentives of farmers to apply diversified crop rotations, mandatory prescription for soil tillage by law, or the lack of coordination between different sectors in the government (Tekle, 2016). . Further, there is limited policy experience and expertise to assist in the transformation of conventional tillage-based systems to CA systems for small and large farmers in different ecologies and national contexts (Milder, 2011; FAO, 2011; Friedrich & Kassam, 2019).

2.2.3.2. Opportunities for the Adoption of Conservation Agriculture in Ethiopia

The government has developed policies and strategies that are pertinent to ensure food security as well as address climate change. The government has moreover ratified international climate change-related conventions (Jirata, Grey, & Kilawe. 2016)... Ethiopia has endorsed several policies supporting Climate Smart Agriculture (CSA), including CA. The Climate Resilient

Green Economy (CRGE) and the National Adaptation Plan Strategies outlined several climate change adaptation technologies of which CA is among them (2ACCA, 2018). According to (Jirata, Grey, & Kilawe. 2016). Opportunities to support the up scaling of CSA and conservation agriculture in Ethiopia include the following

- Regional states have embarked on the promotion of integrated watershed management to improve agricultural productivity, with major emphasis on avoiding open and uncontrolled grazing. This provides a good opportunity for large-scale implementation and promotion of climate-smart practices such as agroforestry and conservation agriculture.
- Resources are available in the form of projects and programmes like AGP, SLM, PSNP and others. These projects are operating in many parts of the country under various agro-ecological zones and farming systems.
- There are private sector organizations and numerous NGOs in the country. At grassroots level there are also adequate numbers of extension and development agents to create climate-related awareness, provide capacity-building training and promote climate-smart agricultural activities.

2.3. Empirical Review

2.3.1. CA and Mulch material

According to Frederic et al. (2016), in conservation agriculture, a practice is said to be sufficiently adopted if and only if at least 30% of the soils surface/plot covered by organic material/crop residues immediately after the planting operation. Actually, this requirement isn’t well satisfied to different farming system in Ethiopia. Nutrient depletion is an overriding constraint in agricultural field due to leaching effect, fixation and crop removal (Habtamu Mengistu, 2018). The rate of replacement is mostly restricted due to certain limitations like poor adoption of soil fertility Management options by farmers and limited supply of organic sources of plant nutrient (Habtamu Mengistu, 2018). These phenomena are known to affects all aspects of crop production and food security at large due to shrinkage in agricultural land. Poor soil fertility status is currently the main constraint to improve crop yields in Ethiopia (Getachewet , 2012; Tewodros and Belay, 2015; Alemayehu, 2006).

There are few studies that have assessed the role of crop residue management on soil properties, crop growth and yield under field conditions in Ethiopia (Tsigie & Tesfaye, 2012). Asefa Taa et al. (2004) reported that stubble burning tended to increase wheat grain yields and decrease the severity of the grass weed Bromus pectinatus infestation compared to partial removal and complete retention of stubble. In contrast, (Bationo. 1993) found that the use of mineral fertilizers without recycling of organic materials resulted in higher yields, but this increase was not sustainable without inclusion of soil amendments. In Ethiopia, alternative uses of crop residues as feed, roof thatching, fencing and other purposes are major constraints, in addition to low biomass productivity of crops in the area, which contribute to continuous nutrient depletion (Tsigie & Tesfaye, 2012). As expected, the proportions of residue use both as feed and soil mulch strongly depends on the size of livestock owned and particularly the number of dairy cows (Moti Jaleta, Menale Kassie, 2012).

2.3.2. Minimum tillage and mechanization

Farmers in Ethiopia have used the Maresha plow for thousands of years (Goe, 1987). It is very simple, light in weight, cheap, and locally made. However, (Leye, 2007) reported that as a conventional tillage implement, the Maresha plow has got several drawbacks which arise mainly from the fact that the plow forms V-shaped furrows and results in incomplete plowing. These drawbacks can have the following effects.

Because of incomplete plowing, farmers have to do repeated tillage in order to produce a fine seedbed especially for tef. As a result, the soil is excessively pulverized resulting in a poor structure crust formation, compaction, etc. Because of repeated tillage at shallow depth, plow pans are formed. The V-shaped furrow exposes a larger surface area of the soil to the atmosphere. Rough surfaces appearing during primary tillage operations enhance gas exchanges CO2 (Reicosky, 2001) resulting in losses of organic carbon. Moreover, evaporation losses are higher due to larger surface area exposure. Conservation tillage systems are believed to reduce surface runoff and maximize infiltration thereby making more water available to crop growth (Ahenkorah,, 1995; Chen, 1998; Steiner, 1998; Rockström and Jonsson, 1999).

A three-year trial conducted to study the effect of frequency of tillage on tef production at three locations in central Ethiopia showed that five times plowing with Maresha (the highest frequency) gave significantly higher grain yield compared to lower tillage frequencies (Tadele , 1999). The authors associated high tillage frequency with the need for the preparation of fine seed bed and for controlling weeds. Reducing tillage frequency was also compensated by use of non-selective herbicide to control weeds. Erkossa, (2006) conducted experiments on reduced tillage using herbicides for *tef* production in the highland verti sols reporting grain yield advantages of 8% over traditional systems.

Gebre, (2001), they reported promising conservation tillage systems but expressed concerns on the affordability of external inputs such as herbicides by resource poor smallholder farmers. Ofori (1993), concluded that the issue of affordability of herbicides is a major setback to the introduction of no-till system in smallholder farming system. Muliokela, (2001) suggested that for resource-poor smallholder farmers in Africa, alternatives to the use of herbicides in conservation tillage.

The Maresha modified conservation tillage implements were developed as modifications to the traditional tillage implement, the Maresha modified Plow, were found to be suitable to the respective operations they were developed for while maintaining simplicity, light weight and low cost nature of the traditional plow.(Leye, 2007). The Maresha modified is used with oxen drawn.

2.3.3. CA and crop rotation

Alemayehu, Shibabaw, Adgo, Asch, & Freyer, (2020b) reported that sound crop rotation plays also a great role in amending soil health and productivity. According to Eugenija et al. (2014), the greatest tuber yield of potato obtained after clover than barley rotation system. Similarly, Malihe et al. (2015) found that potato plants grown in plots following common vetch and faba bean produced 12.7% and 15.0% more tuber yield, respectively, over that of potato grown after winter wheat. Stefano et al. (2010) indicated that clover green manure and farmyard manure substantially increased the total yield of potato by 22.5% and 25.1%, respectively, over the untreated control. In addition, the effect of including legume in the rotation system on improving wheat yield is quite tremendous. According to Talgre et al. (2009), the yield of spring wheat on wheat to wheat rotation system was only 2.12 t/ha but an extra yield of 1.45 t/ha was recorded after Lucerne as a preceding crop. Similarly, Garofalo et al. (2009) reported that the yield increment of wheat following faba bean was above 12% In line with these reports, Ndayegamiye et al. (2015) demonstrated that legumes have significantly increased yields of wheat by 35%. Ali et al. (2015) showed that legumes as preceding crop had significantly elevated grain yield (5.1 t/ha) compared to wheat-wheat (3.18 t/ha) cropping systems.

2.4. Conceptual Framework of the Study

Conservation Agriculture aims at reducing and/or reverting many negative effects of conventional tillage farming practices such as soil erosion (Putte, 2010), soil organic matter decline, water loss, soil physical degradation, According to (Joshi, 2011),the benefits of the conservation agriculture can be seen at farm, regional and national level. The benefits can be classified into three broad categories: (i) agronomic benefits that improve soil productivity; (ii) economic benefits that improve the production efficiency and profitability; and (iii) environmental and social benefits that protect the soil and make agriculture more sustainable. Appropriate institutional arrangements are needed to be evolved so that small and marginal farmers who may not afford to maintain the input and other equipment for practicing conservation agriculture. Integration and the involvement of government agencies, research institutes, financial institutions, non-governmental organizations and private sector (manufacturers and agri-business).

Institutions relating to land and water management, group or cooperative approach for inputs and marketing and value chains and supermarkets are very important as enabling factors in helping agriculture and therefore farmers access inputs in a timely fashion, and selling their outputs (Peron, 2018). They are particularly important in enhancing productivity, sustainability and incomes of small holding agriculture. These institutional support areas include: enabling smallholders farmer groups and cooperatives access high-value markets; provision of a wider range of viable and attractive financial and risk management tools; increasing information dissemination needed for smallholders to increase knowledge and technical skills to take advantage of adaptation strategies (Peron, 2018).

Access to extension services has also been found to be a key aspect in technology adoption. Farmers are usually informed about the existence as well as the effective use and benefit of new technology through extension agents. Extension agent acts as a link between the innovators (Researchers) of the technology and users of that technology. The perception of farmer on CA leads to either uptake or rejection of the CA technology practice practices. The application of CA technology practices may lead improve soil fertility, increase in crop yields and income and diversification of livelihoods.

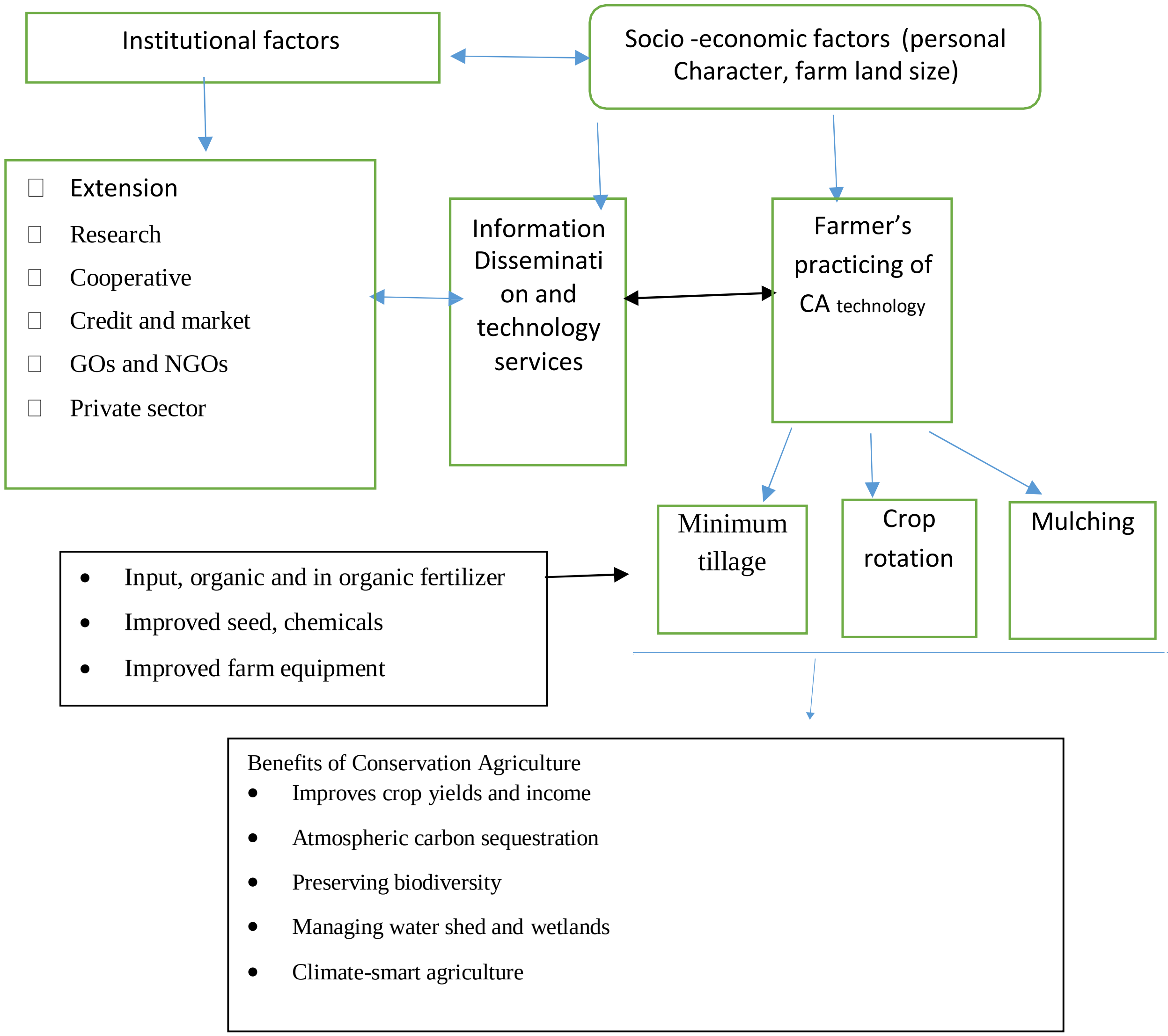

Figure 1.Conceptual framework of institutional and socio economic aspects CA

CHAPTER THREE

3. DESCRIPTION OF STUDY AREA AND RESEARCH METHODS

3.1. Description of Study Area

Before research work the study has been conducted consultation with stake holders doing with conservation agriculture. The main purpose of this consultation is to introduce the research objective to strengthening collaboration and to gather inputs from key stakeholders and discussed the state of conducting of research work in the selected rural Kebeles. The attendees of the consultation were East Gojjam zone agricultural office head, zone experts, Gozamin woreda office head, woreda experts, Rural Kebele chairman and Kebele development agents.

Gozamin woreda is one of the 18 Woredas of East Gojjam Zone in ANRS lies between 100 1′ 46″ and 10035′ 12″ N latitudes and 370 23′ 45″ and 370 55′ 52″ E longitudes. It is found at a road distance of about 300 km Northwest of Addis Ababa and at a road distance of about 250.8 km from Bahir Dar (the capital city of ANRS).

The study area, Gozamin woreda is selected purposively, since the area has done conservation agriculture as compared to the other woredas in in East Gojjam zone. It is one of the Pilot Learning Woredas of conservation agriculture implemented with Gozamin woreda Agricultural Development Office and MSFCSO local NGO project. The choice of Gozamin woreda which has made appreciable strides in promotion and adoption of CA on crop land, provides a great opportunity to explore the application of CA practices and principles for both food security and supporting of agricultural transformation agenda for regional and local development. However, adoption of conservation agriculture technology practice remains low and has not progressed as fast it could have.

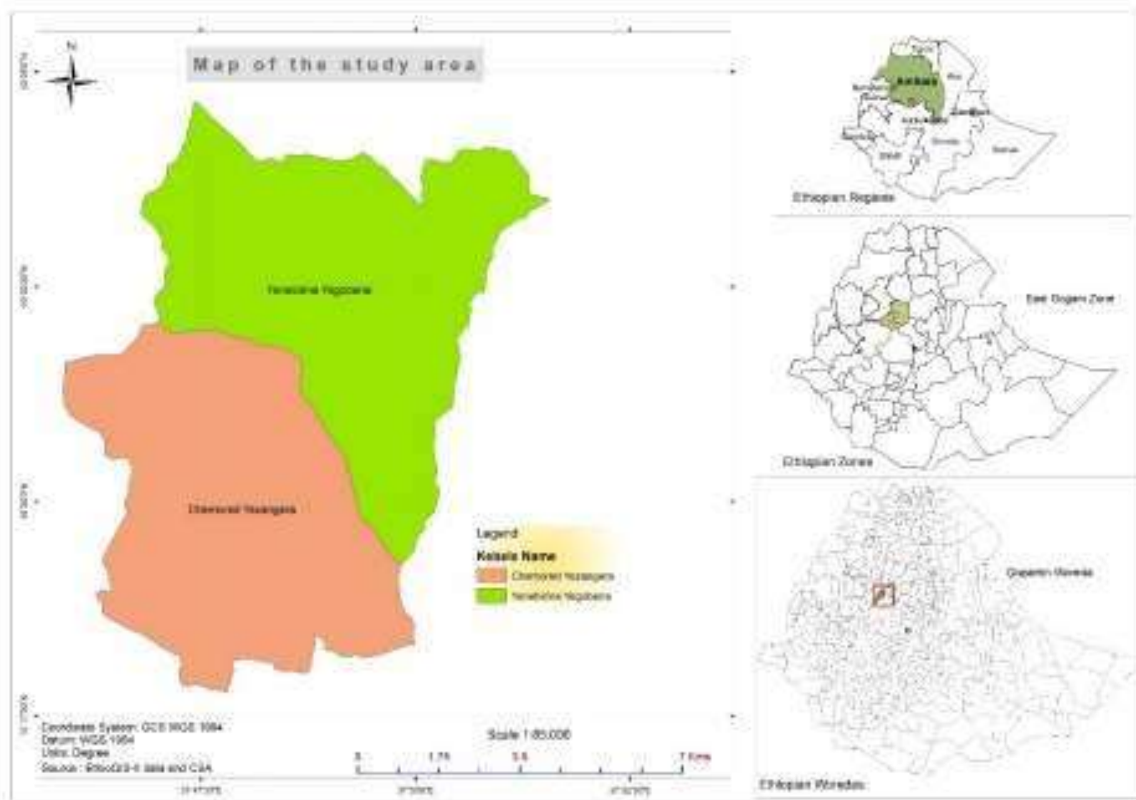

Figure 2.Study area location map (Ethiopian GIS data and Central Statistics Agency)

The woreda has 26 rural kebele and 5 urban kebele). It has 156,279 (50.3% male and 49.7% female) people. From this total population, 98.7% and 1.3% are rural and urban dwellers, respectively. Gozamin woreda is divided in to three traditional agro-climatic zones (i.e., Dega, Woyna Dega and Kola). The southern part is predominantly characterized by Kola climate. Most of the northern and central parts of the woreda are dominated by Woyna Dega agro-climatic zones, whereas the northern tips have Dega agroclimatic zone (GWADO). The elevation of the Woreda ranges between 1200 and 3510-masl (GWADO). The average annual rainfall ranges between 1448-mm and 1808-mm with the mean annual evapotranspiration of 1500-mm. The maximum and the minimum annual average temperatures are 25 and 11 degree centigrade consecutively (GWADO, 2018).

The economic base of Gozamen woreda is agriculture like being normally characterized by mixed farming system which is run by combining crop production and animal rearing together (GWADO, 20118). The most important crops to be produced in the woreda, are cereal crops including wheat (Triticum vulgare), teff, (Era-grostic teff), maize (Zea mays, barley (Hordeum vulgare), white lupine (Lupines albus) and ingido (tinctoria). Gozamen has also 25 FTC in 25

Kebele and on average 3 development agents per kebele or FTC (GWADO, 2018),

3.2. Research Methods

3.2.1. Research Design and Approach

The study followed and employed mixed methods research approach. To address the key research objectives, this study used both qualitative and quantitative methods and combination of primary and secondary sources of data. This study used primary data derived from a household survey conducted and analyzed (the qualitative addressed the process while the quantitative the outcomes). Use of mixed methods also helps to triangulate the reliability of the information which was gathered. Triangulation, i.e., the use of several means (methods and data sources) examined the same phenomenon. This study collected both forms of data at the same time and then integrated the information and interpreted the overall results.

Qualitative data with open-ended without predetermined responses and quantitative data included closed-ended questionnaires used. Semi-structured, structured interview, focus group discussion, key informant interview and personal observation methods has been used and gathered the required data. Therefore, the research questions and objectives addressed by cross-sectional survey data since the study has been done at one season of time and place. Three Data collectors or enumerators trained and guided by the researcher. The enumerators live in the study area and they know well the environment, farmer's culture and norm. The enumerators supervised and cheeked by the researcher.

3.2.2. Data Type and Source

This study used both qualitative and quantitative data type. Both primary and secondary data source has been collected and used in this study. Primary data sources include information collected and processed directly by the researcher, such as observations, surveys, interviews, and focus groups. Secondary data sources include information retrieved through preexisting sources: research articles, Internet or library searches, etc. Primary data were collected from household survey, direct observation, focused group discussion, key informant interview, FGD and post field visit. In addition, Primary data gathered from stakeholders who were involved in Conservation agriculture extension services, input suppliers and NGOs.

Primary data

3.2.2.1. Individual Interview

The researcher had been conducted 95 sample households interviews and addressed the objective of the research. House hold survey interviews were useful and explored an individual's beliefs, values, understandings, feelings, experiences and perspectives of CA technology practice in the study area. Individual interviews also allowed the researcher recognized more about the contextual factors that govern individual experience on CA technology practice.

3.2.2.2. Direct Observation

The study collected direct observation information. It is an effective assessment tool requires consciously using, and recorded, what did observed and heard of a situation or a problem. The direct observation provided this study checked the expressions, feelings and experience of Conservation agriculture technology practices and observed what opportunities are available at the site. This study recognized on the direct observation farmers have high interest to expand CA technologies. The crop land area covered with crop. Most farmers used inter cropping maize with faba bean and haricot been. The area covered with major crops wheat, teff and maize. The grazing land covered with flood and it is muddy, there is a shortage of animal feed. Farmers had been collected teff and wheat straw (crop residues) from the last dry season and used as additional feed for animals.

3.2.2.3. Key informant interviews

Prior to conducting FGDs with community members, three key informant interviews (KIIs) were conducted with subject matter specialists from the woreda, zone and Kebele experts. Key informant interviews (KIIs) also provided information about conservation agriculture technology practice. Participants were purposively selected based on the related field of working. The key informant interviews had been provided information about CA technology practice the success and challenges and other necessary information according to the questioners. The ky informant interview had been done with wored experts, kebele experts as well as MSCFS local NGO project CA expert.

3.2.2.4. Focused Group Discussions (FGDs)

FGDs took place in two kebele (Yenebrina and Chambord). FDGs were organized discussion with two groups of farmers on each kebele. Totally 4 FDGs have been done. Even though this study planed the number of participants on each focused group was 8 to 12 farmers, the study used 3 farmers on each group because of COVID_19 restriction..

Secondary data collection

For the collection of secondary data this study used both published and unpublished data. Published data collected from: i) various publications of the federal, regional, zonal, woreda and rural kebele office (e.g., census reports, annual reports and reports of government departments), ii) various publications of foreign governments or of international bodies and their subsidiary organizations (FAO, UNO, IFAD, ILO). iii)Various research reports IV) Books of various authors, magazines, and newspapers, v) various sources from university libraries.

3.2.3. Sample Frame and Sampling techniques

The choice of Gozamin woreda which has made appreciable strides in promotion and adoption of Conservation Agriculture on crop land, provides a great opportunity to explore the application of CA practices. It is one of the Pilot Learning Woreda in Amahara Region East Gojjam zone for the implementation and adoption of CA technology practice CA implemented with woreda agriculture development office and MSCFSO local NGO project. The study area is selected to investigate the CA practice application constraints, opportunities and contribution on major crop productivity since the technology is new in this areas. The woreda has 26 rural kebele and 4 towns. Among these 26 rural kebele conservation agriculture implemented in four rural kebele (Chimbord, Yenbirina, .Enerata and Giraram). These four kebele have similar Woyina Dega agro ecological zone. Sample kebeles selected through the consultation woreda Agriculture Office. From the above mentioned four CA implementation kebeles (Chimbored and Yenebirina) were selected based on their accessibility and represent the remaining two kebeles. The selected two rural kebele (Chimbored and Yenebirina) have 915 and 831 households respectively.

The first consideration defined the target population in the selected kebele. Checked and arranged resent list of households from the Woreda and Kebele agriculture office and the sample took from this lists.

Random sampling method was used to select sample of households. A total of 95 households sample respondents were selected for the investigation. The sample size of this research is calculated by using Taro Yamane (Yamane, 1973) formula with 90% confidence level (Yamane & Yamane, 2012).

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

Where

n= sample size required

N = number of people in the population e = allowable error (%)

Therefore the number of households in the population in the selected two kebele (Chimbored and Yenebirina) is 1,746. And the number of sample size is 95. Determination of sample size indicated in formula (1) and (2)

Formula (1): n= 1746/1+1746 (0.1x0.1) = 95

The required sample households of each kebele (n) were, calculated using Formula (2): n1= N1 (n)/ ∑N and the sample size from each Kebele

Chimbord n1 = 915 (94)/1746 = 50 house holed sample Yenebirina n1 = 831 (94)/1746 = 45 house holed sample

3.2.4. Method of Data Collection

This study used both quantitative and qualitative Primary data collection methods. Qualitative data with open-ended without predetermined responses and quantitative data included closed-ended questionnaires used. Semi-structured, structured interview, focus group discussion, key informant interview and personal observation methods has been used and gathered the required data.

Data Gathering Tools: structured and Semi-structured interview, closed ended and open ended questions were utilized for questionnaire respondents and collected information from primary sources.

Structured interview: - Structured interviews enable the interviewer to ask each respondent the same questions in the same way. A tightly structured schedule of questions was used, very much like a questionnaire. The questions contained in the questionnaire planned in advance. Close ended questions have specific answers, which are normally short, with yes/no or categorical answers. They are generally easy to aggregate and analyses as they do not required complex recoding operations.

Semi structured interview:-Semi-structured interviews involved a series of open- ended questions based on the topic areas the researcher wants to cover. The open- ended nature of the question defined the topic under investigation. It is used and provided opportunities for both interviewer and interviewee discussed in more detail.

Pre Tested: Pre tested Semi-structured interview were collect data from the respondents. The interview schedule was pre tested on non-randomly selected households. Interviewers, who know the area very well, were recruited and trained about the objectives of the study, methods of data collection and interviewing techniques and ethics. Then they did collect the data from sample farmers with the supervision of the researcher.

Units of Analysis

The unit of analysis were individuals (household survey), groups and institutions. Individuals (household survey) are the most typical units of analysis in this research. The next levels of units of analysis are groups of individuals. A group means two or more people who interact with each other, share same characteristics and have sense of unity. After groups of individuals, other units of analysis are organizations. Organizations refer to formally structured groups or institutions. In this study institutions like agricultural office, farmer's cooperatives, financial services and others included in this unit of analysis.

3.2.5. Method of Data Analysis

The data has been summarized, coded and interred the data into in to STATA software version 12. This study used descriptive statistics and Econometric method of data analyses tools. Descriptive statistics (frequency, percentage, mean and standard deviation). Econometric analysis Logistic regression is a class of regression where the independent variable is used to predict the dependent variable. This study used ordered logic to take advantage of the ordinal nature of the dependent variable. The use of the ordered logit is appropriate when the dependent variable involves more than two alternatives that must take a logical ordering.

3.2.5.1. Model Selection

Econometric models was specified and used to identify the determinants of conservation agriculture technology practice. The dependent variable is major crop productivity under CA technology practice. Explanatory or independent variables are age, gender, education, access to input, access to agricultural extension services and percent of area covered under CA practice Using order logit model, the factors that influence households' decisions of CA technology practice on crop productivity was estimated. The ordered logit models have a dependent variable that are ordered categories. Examples include rating systems of crop productivity (medium yield increment, high and highest increment of crop productivity).The logistic regression model explores the socio-economic and institutional factors influencing major crop productivity under CA technology practice. Seven independent variables were hypothesized and analyzed about the dependent variables of farmers' decision on crop production and productivity under CA technology practice on major crops (maize, wheat, teff and faba bean).All variables were entered to the model.

3.2.5.2. Description of Dependent Study Variables

For this study the dependent variable Crop productivity under CA technology practice explained as framers has been practiced CA technology, practiced the three CA principles (no-tillage, crop rotation, and mulching), was observed by the surveyor and determined according to the data analysis result. The dependent variable crop productivity under CA technology practice categorized into low, medium, high and higher increment of crop productivity.

3.2.5.3. Description of Explanatory Study Variables

The factors related to the characteristics of producers (farmers) include, age, gender (sex) and educational level, The institutional factors include access to input, availability and frequency of extension advisory services, availability of mulch materials and, percent of area covered under CA technology practice Demographic factors under this Sex is demographic factors and this study consider Male Headed and Female headed Households in the study. Age of the household head is another variable in explaining farmers 'technology adoption behavior which plays an important role through influencing farmer's information access and shaping their ability to change the available information into action (Sci & Res, 2018). The socio- economic- factors considering education status of the household head is the most common and important variable that is found to explain farmers. CA technology practice application behavior.

Institutional factors deal with the extent or degree to which institutions impact on level of CA technology practice by small-holders. Institutions include all the services to agricultural development, such as finance, insurance and information dissemination. They also include facilities and mechanisms that enhance farmers' access to productive inputs and product markets. Extension service is a very crucial institutional factor that differentiates adoption status among farmers (Sci & Res, 2018).

Table 1. Definition of variables

Definition of variables			
No	Variable name	Description and measurement type	
	Dependent variable		Variable type
1	Crop Productivity under CA practice	Farmers' perception on Quantity of productivity Q.t/ha on major crops (maize, fababean wheat and teff harvested over area of CA farm practiced(1= medium increment , 2 = high increment , 3 = higher increment)	categorical
2	Independent variables		
2.1	Gender (sex)	1 = female household head , 0 = male	categorical
2.2	Age (age group)	Age group of household head 1 = not young,(greater than or equal to 35) young below 35 = 0	categorical
2.3	Education	Level of education in the household 1 = not read and write, 2 = read and write, 3 = religious education, 4 = grade 1 to grade 2, 5= grade 3 and above.	categorical
2.4	Percent of area of crop land covered with CA practice	Percent (%) of area covered with CA from the total cultivated land	continuous
2.5	Frequency of Extension advisory services	Frequency of Extension advisory services per month	continuous
2.6	Access to input and credit services	1 = access to fertilizer, improved seed and chemicals, 2 = access only fertilizers and improved seed	categorical
2.7	Availabilities of crop residues and mulch materials	1 = very low, 2 = low, 3 = medium	categorical

Source: Survey result, 2020

CHAPTER FOUR

4. RESULTS AND DISCUSSIONS

This chapter presents the analysis and interpretation of survey data on major crop productivity under CA technology practice. The study analysis result organized in to two parts, descriptive and Econometrics analysis.

4.1. Descriptive Statistics Data Analyses

This part clarifies the analysis of

- Socio-economic and instructional drivers, of CA technology practice
- Contribution of CA technology practices to crop productivity
- Challenges and opportunities of CA technology practices

4.1.1. Socio- Economic and Institutional Drivers of CA Technology Practice

4.1.1.1. Gender (Sex)

The participants were small holder farmers practiced CA technology in Chombord and Yenbirina rural kebele in Gozamin woreda. Interview participants were 86 % male and 14 % female households (table two).

Table 2. Descriptive statistics of Gender (sex) of households

Sex	Frequency	Percent	Cum
Female	13	13.68	13.68
Male	82	86.32	100
Total	95	100	

Source: Survey result, 2020

4.1.1.2. Age of Households

The variable age is hypnotized to affect crop productivity with CA technology practice. Young age group or youth (those aged 25 to 34 years) and not young or mature individuals (age 35-64 years), (Schmidt & Bekele, 2016). In this study (table 3) age is categorized into young age group less than 35 and not young age group greater than or equal to 35 years old. From the total respondents (44.21%) had less than 35 years old (young age group) and (55.79 %) had 35 and above years old (not young age group)

Table 3. Descriptive statistics age of households

Age Group	Frequency	Percent	Cum
Young	42	44.21	44.21
Not Young	53	55.79	100.00
Total	95	100	

Source: Survey result, 2020

Table 4 Descriptive statistics of crop productivity with age group

Crop productivity	Young	not young	Total
Medium increment	1	10	11
High increment	21	41	62
Higher increment	20	2	22
Total	42	53	95

Source: Survey result, 2020

4.1.1.3. Crop productivity with CA technology practice and age group

The woreda agricultural development office with MSCFSO local NGO linked promotion of CA technology practice to improve crop productivity of small-holder farmers. (Table 4) indicates that the sampled respondents on major crop productivity 11 individuals responded that crop productivity medium yield increment (1 young and 10 not young), 62 individuals responded high increment (21 young and 41 not young), and 22 individuals with higher yield increment (20 young and 2 not young).

Age of the household head is a variable in explaining farmers technology adoption behavior which plays an important role through influencing farmers information access and shaping their ability to change the available information into action. Older farmers may have experience and resource that would allow them more possibilities for trying a new technology. On the other hand, younger farmers are more likely to adopt new technology because they have had more schooling than the older generation (Sci & Res, 2018).This study result show higher yield increment crop production has been produced with young age groups through CA technology practice.

Education

Table 5 shows respondents their educational level not read and write 10 individuals (10.53%), read and write 24 individuals (25.26%), religious education 12 respondents (12.63 %), grade

1 to 2 educational level 28 respondents (29.47%) and educational level grade three and above 21 respondents (22.11%).

Table 5 .Descriptive statistics of household' educational level

Education	Frequency	Percent	Cum
Not read and write	10	10.53	10.53
Read and write	24	25.26	35.79
Religious education	12	12.63	40.42
Grade 1 and 2	28	29.47	77.89
Grade 3 and above	21	22.11	100
Total	95	100	

Source: Survey result, 2020

Table 6. Descriptive statistics of crop productivity and education in number

Crop productivity	Not read and write	Read & write	Religious education	Grade 1 and 2	Grade 3 & above	Total
Medium yield increment	10	0	1	0	0	11
High increment	0	24	11	15	12	62
Higher increment	**0**	**0**	**0**	**13**	**9**	**22**
Total	10	24	12	28	21	95

Source: Survey result, 2020

4.1.1.4. Education and crop productivity of CA technology practice

Table 6 shows from the total respondents 11 individuals under the category of medium yield increment of crop productivity with educational level not read and write10 and religious education one. From the total respondents 62 under the category of high yield increment of crop productivity with educational level read and write 24, religious 11, grade 1 and two 15, grade 3 and above 12. From the total respondents 22 under the category of higher yield increment of crop productivity with educational level grade one and two 13, grade three and above 9. Education status of the household head is the most common and important variable that is found to explain farmer agricultural technology adoption behavior (Schmidt & Bekele, 2016).

Several studies indicate that educational level of farming HHs has a positive association with utilization of new technologies and farming practices (Agajie, Mesfin, Getu, Aemiro, 2004). Various studies confirmed that it has a significant positive influence on adoption of technologies. For instance, Mahadi et al. studied factors affecting adoption of improved sorghum varieties in Somali Region of Ethiopia. This study shows education level of the household head was used as a proxy for a farmer's ability to acquire and effectively use information. It is a measure of human capital development and enables an individual farmer to have access to information and make informed decisions for new t technology adaptation. This study result indicated that from the total respondents 22 under the category of higher yield increment of crop productivity with educational level grade one and two 13, grade three and above 9.

4.1.1.5. Access to agricultural input

As indicated (table 7) out of 95 sample respondents 63% accessed to input (fertilizer, chemical and improved seed), 67 % access to input (improved seed and fertilizer) but not access to agro chemicals. On the other hand the whole household sample respondents did not have access to improved farm equipment for CA technology practice. Farm implements in CA production used only cultural materials of plough, sowing and harvesting. This is one of the challenges of CA technology practiced adoption and scaling up. Institutional factors deal with the extent or degree to which institutions impact on technology adoption by smallholders. Institutions include all the services to agricultural development, such as farmer's access to productive inputs.

On the demand side, the cost of creating fertilizer markets is high where final consumers are widely dispersed geographically or where their small landholdings and limited cash resources mean that they purchase only small quantities of fertilizer, which are more costly for retailers to sell (Jayne et al. 2003; Harrigan 2008). On the supply side, the considerable economies of scale in international procurement and shipping imply that fertilizer importers require a high degree of liquidity to procure for the supply chain (Spielman, Mekonnen, & Alemu, 2013). In this study even though out of 95 sample respondents 63% accessed to input (fertilizer, chemical and improved seed), the key informant interview and focused group discussions explained the price of input is high. Therefore farmers did not use the recommended rate of input specially fertilizer and chemicals.

Table 7. Descriptive statistics of access to input

Access to input	Frequency	Percent	Cum
Access to fertilizer, improved seed and chemicals	60	63.16	63.16
Access to improved seed and fertilizers	35	38.64	100
Total	95	100	
Access to farm equipment	Frequency	Percent	Cum
Access	0		
not access	95		100
Total	95	95	

Source: Survey result, 2020:

4.1.1.6. Availability of mulch materials

Table 8 indicated sample respondents of 17 individuals (17.89 %) responded very low availability of mulch materials, 57 individuals (60%) responded low availability of mulch materials and 21 individuals (22%) responded availability of mulch materials medium.The study on crop residue for improving fertility of soil in north shewa zone degem woreda by (Agajie, Mesfin, Getu, Aemiro, 2004) indicated , Owing to shortage of animal feed, free grazing of animals in the farmlands after harvesting of crops is a common source of feed in the study areas. This practice has led to overgrazing, which is one of the causes of soil erosion. It was noticed that the farmers realize the role of crop residue to control soil erosion. However, free grazing practice has become a detrimental problem to leave crop stubbles in the field to minimize soil erosion by both flood and wind. This indicates that households does not use crop residue intentionally to improve the fertility of the soil due to the critical feed shortage in the area (Agajie, Mesfin, Getu, Aemiro, 2004). Similarly this study result shows, respondents with very low and low availability of mulch materials responded there were less availability of crop residues mulch materials. They used only green manure and intercropping with low and very low crop residue materials. This indicated there is challenging of free grazing, cattle released on crop land after harvest of crop and computed CA mulch materials which is decreased accessed to crop residue mulch materials.

Table 8. Descriptive statistics of Availability of mulch materials

Availability of mulch materials	Frequency	Percent	Cum
Very low	17	17.89	17.89
Low	57	60	77.89
medium	21	22.11	100
Total	95	1200	

Source: Survey result, 2020

4.1.1.7. Agricultural extension advisory services

The woreda agricultural development office with MSCFSO local NGO linked promotion of CA technology practice to improve crop productivity of small-holder. The summery statistics for continuous variables out of 95 respondents under (table 10) shows that the mean frequency of extension advisory service by Development Agents (DA) visit per month minimum 1.7, and maximum 3 times. Extension service is a very crucial institutional factor that differentiates adoption status among farmers. In the existing situation much of agricultural technology delivery is undertaken by the extension system (Sci & Res, 2018). Study conducted in four regions of Ethiopia show that farmers who had more frequent contact with extension agents were more likely to adopt wheat technology as compared to farmers who had low frequent contact (efera T, Tesfay G, Elias E, Diro M, Koomen , 2016). Institutions include all the services to agricultural development, such as finance, insurance and information dissemination. They also include facilities and mechanisms that enhance farmers' access to productive inputs and product markets (Sci & Res, 2018).

In this study the key informant interview (experts from woreda and Kebele) explained the advisory services is not included multi discipline manner. There is limitation of integration of CA technology with farm implement mechanization of plowing, sowing and harvesting equipment Small holder farmers used only cultural materials. This shows the extension advisory service did not introduced improved farm equipment for small holder farmers.

Table 9. . Descriptive statistics of percent of area under CA technology practice

Percent of area covered under CA	Frequency	Percent	Cum.
3	1	1.05	1.05
12	1	1.05	2.11
13	5	5.26	7.37
17	5	5.26	12.63
20	1	1.05	13.68
25	21	22.11	35.79
29	1	1.05	36.84
33	18	18.95	55.79
38	4	4.21	60
43	2	2.11	62.11
50	28	29.47	91.58
57	1	1.05	92.63
67	2	2.11	94.74
100	5	5.26	100
Total	95	100	

Source: Survey result, 2020

4.1.1.8. Crop productivity and percent of area covered with CA practiced

Table 10 Shows that .the mean percent of cultivated area covered under CA from the total cultivated land 38.58%., minimum percent of area covered under CA practice 3 and maximum100. Table 9 indicated that the minimum present of area covered under CA technology practice 3 respondents (1.05%) and the maximum percent of area covered under CA technology practice 5 respondents (5.26%).

Table 10. Descriptive summary statistics of continuous explanatory variables

Variable	Obs.	Mean	Std. Dev.	Min	Max
Percent of area covered under CA	95	38.55	19.82679	3	100
Frequency of extension visit per month	95	1.716	0.476315	1	3
Teff Frequency of tillage under CA practice	95	3.116	0.32167	3	4
Wheat frequency of tillage under CA practice	95	3.032	0.307794	2	4
Maize frequency of tillage under CA practice	95	2.589	0.494539	2	3
Teff Frequency of conventional tillage	95	6	0.483779	5	7
Wheat frequency of conventional tillage	95	4.989	0.23039	4	6
Maize frequency of conventional tillage	94	4.085	0.280536	4	5

Source: Survey result, 2020

Conservation agriculture is the group of crop management practices promoted to increase crop yields and to reduce soil degradation and develop system which is more resilient to weather – induced stresses including those caused by climate change and climate variability (Thapa, Khanal, & Marahatta, 2019).

Table 11 shows households responded medium increment of crop productivity their mean percent of area covered with CA practiced 41, high increment of crop productivity mean percent of area covered with CA practiced 34 and higher increment of crop productivity mean percent of area covered with CA practiced 50. This result shows that there is strong relationship between crop productivity and areas covered with CA practiced. The more area covered with CA higher increment of crop productivity. The respondents explained the advantage of CA practices such as decrees crop land soil erosion, improve soil moisture, resilient to drought during the dry season and crop yield improvement. Although the cultivated area covered with CA improve crop productivity, the area coverage is not expand (farmers did not cover the whole cultivated land with CA). This is due to luck of mulch materials and did not support with improved farm equipment.

Table 11 Descriptive statistics of crop productivity with area covered under CA technology

Crop productivity	Mean (percent of area covered under CA)	sd of (percent of area covered under CA
Medium yield increment	41.1818	25.45906
High yield increment	34.0968	13.97974
Higher yield increment	49.7727	26.25141

Source: Survey result, 2020

4.1.1.9. Crop productivity With CA technology *practice*

Table 12. Descriptive statistics of Category of respondents on crop productivity under CA

crop productivity	Freq.	Percent	Cum.
Medium yield increment	11	11.58	11.58
High yield increment	62	65.26	76.84
Higher yield increment	22	23.16	100
Total	95	100	

Source: Survey result, 2020

The major crops in the study area are wheat, teff,, maize and faba bean. The productivity of major crops with CA practiced in the study area (table 12) shows that 11 households (11.58%) response was medium yield increment, 62 households (65.26 %) responded high yield increment and 22 number of respondents (23.16%) responded higher yield increment of crop productivity. This indicates most of the respondents responded in high increment and higher yield increment of crop productivity categories. The descriptive result shows crop production with CA practice has positive effect on crop productivity hence in the study area respondents recognized and understand CA technology practice and its contribution for crop production. Members of farmers focused group discussion explained CA technology practice improved the soil moisture retention, amend soil fertility and increase crop productivity. In addition during the dry spell and early cessation of rain fall before the crop mature the CA farm reduced the crop frailer. Whereas the main challenge is shortage of mulch materials. After harvesting of crops the residues feed for animals. Not only dead mulch crop residues but also live mulches destroyed by free grazing due to this farmers did not cover most of their cultivated land with CA technology.

4.1.2. Contribution of CA Technology Practice to Crop Productivity

4.1.2.1. Crop Rotation practice

Results of the study by (Alemayehu, Shibabaw, Adgo, Asch, & Freyer, 2020a) clearly demonstrated that.in three year period (2013‐2015), sound crop rotation practices and manure applications attributed to improve soil bulk density, pH, CEC, organic carbon, total nitrogen, available phosphorous, and exchangeable potassium on average up to 23%, 18%, 67%, 89%, 150%, 89%, and 44%, respectively. Similarly, the combination of these practices rendered to improve the productivity of potato and bread wheat on average up to 540% and 446%, respectively.

Crop rotation is improve soil fertility and reduce insect pest and disease In the study area farmers were used crop rotation practices cereal crops (wheat, maize and teff) with legumes crops like faba bean, haricot bean and lupin. Out of the respondents (on table 13) 17.89% responded crop rotation were used rarely, 55.79 % frequently and 23.32 % more frequently. The result shows that farmers have cultural experience and recognized the use of crop rotation and improve crop productivity.

Table 13 Descriptive statistics of crop rotation

Crop rotation	Freq.	Percent	Cum.
Rarely	17	17.89	17.89
Frequently	53	55.79	73.68
More frequently	25	26.32	100
Total	95	100	

Source: Survey result, 2020

4.1.2.2. Minimum Tillage Practice

Getachew Sime, (2015) who reported an increased grain and stover yield of maize in four times tillage compared to the minimum tillages (zero and one) in the central rift valley of Ethiopia. Similarly, Taa et al. (2004); and Borin and Sartori (1995) observed lower yields in wheat and maize, respectively in minimum and zero tillage than conventional tillage. However, the review work of Worku Burayu et al. (2001) found maize grain yields lower on conventional tillage compared to conservation tillage in Ethiopia. According to (Tsegay, Kidane, Tesfay, & Kahsay, 2018) study results and others' findings, it can be suggested that although conservation tillage (no tillage) is proposed for many advantages: increase stored soil water by conserving the soils' natural structure and by reducing soil evaporation; increase soil fertility by minimizing soil erosion and increasing soil organic matter, its effect on yield is rather a long term (increase over time) that contrasts with the farmers' intension. Thus, extensive on-farm experimentation in participatory approach is required to adopt the technology by the farmers.

Farmers in the study area plowed the farm land many times to make the land more suitable for crop production through conventional tillage practices (table 10).For example, conventional tillage for teff 5 -7 times and mean 6, whereas the mean tillage frequency of CA for teff is 3.03, minimum 3 and maximum 4 times. Conventional tillage for maize 4-5 times and mean 4, whereas the mean tillage frequency of CA for maize is 2.59, minimum 2 and maximum 3 times frequency of tillage. Conventional tillage frequency of wheat 4-6 times and mean 5 times. On the other hand the mean tillage frequency of CA for wheat is 3, minimum 2 and maximum 4 times. CA technology practice reduced the number of tillage frequency as compared to conventional tillage. Members of farmers focused group discussion explained about the use of minimum tillage reduce of oxen plough cost, decrease soil erosion and increase soil moisture.

4.1.2.3. Mulching Practice

Application of mulch has high potential to conserve soil moisture that halt the moisture from soil particles, facilitate infiltration and hinder runoff. Mulch also contributes to water conservation through addition of organic matter that improves soil aggregation and porosity and as a physical layer covering soil to reduce splashing of soil when rain dropping, surface runoff and evaporation (Fikre A, Ayana M, Alaro A, Mamo G, 2018). Therefore, mulching is one of the promising technologies that is an integral component of conservation farming and is increasingly seen in the light of integrated soil management for sustainable agriculture. Even though mulch is decisive factor for crop production farmers in the study area faced with constraints of mulch materials.

4.1.3. Challenges and Opportunities of CA Technology Practices

4.1.3.1. Opportunities of CA Technology Practice

Conservation agriculture has been considered as the potential not only to increase the sustainability of agricultural productivity, but also to help works toward mitigation and adaption of climate change (Abebe, Bedadi, & Bekele, 2020.).

According to this study observation there are opportunities to implement CA technology practices. The key informant interviews, focused group discussions and field observations indicated the opportunities as follows.

- At kebele level there are also adequate numbers of development agents (kebele expert to facilitate CA technology practices.
- The CA technologies has been practiced 3 – 4 years and the woreda and Kebele expert as well as farmers have experienced.
- Supported with MSCFS local NGO organizing with local governments develop skill on CA technology. Experience sharing of farmers to farmers
- Provided capacity-building training and promote climate-smart agricultural activities.

4.1.3.2. Challenges

- .Free grazing practice has become a detrimental problem to leave crop stubbles in the field to minimize soil erosion by both flood and wind and to increase the fertility of soil. Less availability of mulch materials.
- The extension advisory service There is limitation of integration of CA technology with farm implement mechanization of plowing, sowing and harvesting equipment Small holder farmers used only cultural materials
- The extension advisory services is not included multi discipline manner. There is limitation of integration of CA technology with farm implement mechanization of plowing, sowing and harvesting equipment Small holder farmers used only cultural materials.

4.2. Results of Econometric Analysis

An ordered logistic model is estimated to investigate the factors influencing household crop productivity under CA technology practice category. Different categories have been developed to classify levels of crop production and productivity under CA practices. The category of household crop production and productivity under CA practice is based on crop production and productivity. Order Category a household perception of crop productivity classified into medium yield increment, high yield increment and higher yield increment of crop productivity. Ordered logit is used to take advantage of the ordinal nature of the perception of household crop productivity under CA technology practices. For example, a household in high yield increment of crop production category is “worse off” than a household in the higher yield increment of crop production, but they are better than medium increment of crop productivity household’s category.

The use of the ordered logit is appropriate when the dependent variable involves more than two alternatives that must take a logical ordering. Following Greene (2003), the ordered logit model can be determined by

$$Y^*i = xi\ \beta + \varepsilon\ i = 1 \ldots N \text{ households,}$$

Where i refers to the observation (i.e., Household), Y*i is latent variable (i.e., unobservable) that represents the crop productivity under CA practice of farmer i, Xi is a vector of socio-economic and institutional variables including a constant, β is a vector of parameters to be estimated and ε are the random error terms assumed to be standard normal distributed. Since Y*i is latent (unobserved), we observe responses of the variable Y*i as follows

Yi = 1 (medium increment of crop productivity) if Y^*i is $\leq \alpha_1$ Yi = 2 (high increment of crop productivity) if $\alpha_1 \leq Y^*i \leq \alpha 2$ Yi = 3 (higher increment of crop productivity) if $Y^*i \leq \alpha_3$

α, unknown parameters to be determined with β with three dependent variable categories, two cutoff points are estimated. The logistic model is estimated for the crop production under CA practice models using maximum likelihood techniques programmed in STATA version 12. Crop production under CA practice model included seven independent variables. The parameter of the ordered logit model is estimated by the maximum likelihood method and reported the odds ratio of the variables.

Table 14.Order logit result of crop productivity under CA practice

```
Ordered logistic regression                     Number of obs   =         95
                                                LR chi2(7)      =     101.35
                                                Prob > chi2     =     0.0000
Log likelihood = -31.68265                      Pseudo R2       =     0.6153
```

crop productivity	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
age group	.0606761	.0535935	-3.17	0.002	.0107442	.3426571
education	8.572973	4.479374	4.11	0.000	3.078783	23.87173
gender	.2533766	.2672193	-1.30	0.193	.0320672	2.002036
ofareaunderca	1.036045	.0172945	2.12	0.034	1.002697	1.070502
fofexvisit	.827805	.6147853	-0.25	0.799	.1930931	3.548863
accetoinput	.1224825	.1031814	-2.49	0.013	.0234967	.6384706
avcrmulchmaterial	4.36925	2.811989	2.29	0.022	1.237614	15.42512
/cut1	-.8641852	2.691398			-6.139229	4.410859
/cut2	9.497249	3.292739			3.043598	15.9509

Source: Survey result, 2020

Table 15 Pseudo R2 = 0.615 the dependent variable crop productivity under CA practice can be explained by the independent variables by 62%. The LR chi_ squared test with value of 101.35 (P-value = 0.0000) show that model fits the data well. Age group, education, percent of cultivated area under CA practice, access to input and availability of crop residues and mulch materials are statistically significant. Gender (sex) and frequency of extension visit is not statically significant.

Link test for model specification was computed using Stata12 version. For this case, based on the results of the link tests on table 16 the p value for hat square is higher than 10 % significance level it shows no model specification problem and availability of crop residues and mulch materials are statistically significant. Gender (sex) and frequency of extension visit is not statically significant

Table 15. Model specification link test

Ordered logistic regression				Number of obs	=	95
				LR chi2(2)	=	101.39
				Prob > chi2	=	0.0000
Log likelihood = -31.662427				Pseudo R2	=	0.6155

crop productivity	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_hat	1.046603	.3068197	3.41	0.001	.4452471	1.647958
_hatsq	-.0042272	.0211421	-0.20	0.842	-.0456649	.0372104
/cut1	-.8917731	.5591265			-1.987641	.2040947
/cut2	9.555949	1.829508			5.970179	13.14172

Source: Survey result, 2020

Crop productivity under CA practice (dependent variables) are categorized in this study based on the extent of implementation of CA practice on the farms. The main socio-economic and institutional variables expected to influence CA practice that were analyzed in this study are percent of cultivated land covered under CA, mulch materials, access to input, age group, Frequency of extension visit and advisory services, educational level of farmers.

Age group, education, percent of area of cultivated land covered under CA, access to input and availability of mulch materials have a positive and significant influence on crop productivity under CA practice . These independent variables are important for a farmer to improve the crop productivity under CA practice whether to go from medium increment of crop productivity phase to the high and higher increment of crop productivity.

4.2.1. Age

The marginal probability of young age group have crop production under CA technology practice 58% and not young 34%. The study result indicated that young age group have more probability of crop production under CA technology than not young (table 17). Age group has an influence on crop productivity under CA practices. This suggests that More households with young age group categorized under high and higher increment of crop productivity than not young age group This can be explained by the fact that the young age groups practiced the technology better than not young age group.

4.2.2. Education

The marginal probability of education not read and write get crop production under CA technology 33 %, read and write 14 %, Religious education 33%, grade 1 and two 0.4% and grade three and above 0.06 % (table 17). The probability of educational level not read and write have been used crop production under CA technology 33%. Similarly the probability of religious educational level have been used crop production under CA technology practice 33%. Whereas the probability of educational level grade one and two, grade three and above is less than 33 %.

4.2.3. Access to input

This study shows that access to input influences CA practice and crop productivity, indicated that farmers who have no access to input are less likely to practice CA measures. The marginal effect of access to agricultural input for fertilizer, seed and chemicals have crop production under CA technology 1.4 %, and the probability of seed and fertilizer only without chemical has been used crop production under CA technology 6%. Accessibility of inputs for seed and fertilizer only without chemical have more probability of crop production under CA technology than access to seed, fertilizer and chemicals (table 17).

4.2.4. Availability of mulch materials

Crop residues are materials left on cultivated land after the crop has been harvested and other mulch materials have positive significant effect on crop production under CA technology practice. This variable is important for a farmer to decide whether to go from the medium yield increment phase to the high and higher increment of crop productivity crop productivity phase under CA technology measures.

The probability of availability of mulch materials very low get crop production under CA technology practice 17%, low 9% and medium 4% (table 17). The change in the marginal probability when availability of mulch materials goes from ‘medium to ‘ low increases by 9% and from medium to very low increase by 17%. The marginal probability of availability of mulch material has been used for crop production under CA technology 17% used very low availability of mulch material, 9% low and 4%medium. The study result indicated farmers produced crop under CA technology with very low availability of mulch materials is greater than low and medium. They used only green manure and intercropping with low and very low crop residue materials. This indicated there is challenging of free grazing, cattle released on crop land after harvest of crop and computed CA mulch materials which is decreased accessed to crop residue mulch materials. Besides, the probability of percent of area covered with CA has an average 11% under CA technology crop production.

Although crop residues is important for CA technology practice, farmers have integrated crops and livestock farming systems, resulting in competition for crop residues, decreased the use of crop residue application to the CA farm. The majority of the farmers indicated that free grazing was the main contributor to decrease availability of crop residues for CA technology framing. Most of the farmers use live mulch like cover crops, green manure and inter cropping to improve soil covers rather than crop residues after harvest (dead mulch) due to free grazing.

Availability of mulch material crop production under CA technology very low 17 %, low 9% and medium 4%. This the study result indicated farmers produced crop under CA technology with very low availability of mulch materials is greater than low and medium. The probability of percent of area covered with CA get an average 11% under CA technology crop production.

Table 16. Marginal effect of independent variables

		Delta-method					
	variables	Margin	Std. Err.	z	P> /z/	(95% C.I)	
education	Not read and write	0.337109	0.085068	3.96	0	0.170378	0.50383
	Read and write	0.142155	0.039518	3.6	0	0.064702	0.21960
	Religious education	0.033505	0.018367	1.82	0.068	-0.00249	0.06950
	Grade 1 and 2	0.004685	0.00422	1.11	0.267	-0.00359	0.01295
	Grade 3 and above	0.000561	0.000695	0.81	0.42	-0.0008	0.00192
Age group	young	0.57912	0.310032	1.87	0.062	-0.02853	1.18677
	not young	0.337109	0.085068	3.96	0	0.170378	0.50383
Access input	Fertilizer, seed, chemical	0.014503	0.018122	0.8	0.424	-0.02102	0.05002
	Fertilizer and seed only	0.059865	0.026385	2.27	0.023	0.008151	0.11157
availability of mulch	very low	0.167397	0.046881	3.57	0	0.075512	0.25928
	low	0.092548	0.025668	3.61	0	0.042241	0.14285
	medium	0.04339	0.030878	1.41	0.16	-0.01713	0.10391
percent of cultivated Area under CA		0.111707	0.019294	5.79	0	0.073892	0.14952

Source: Survey result, 2020

CHAPTER FIVE

5. Conclusion and recommendations

5.1. Conclusions

In this study, crop productivity with CA technology practice measures is categorized into three major phases, i.e., medium, high and higher increment of crop productivity. The study indicates that sample households find themselves in different phases of crop productivity due to different institutional and socio-economic factors. The study shows that medium increment, high and higher increment of crop productivity with CA technology practice are mainly due to availability of mulch materials, access to input, level of education and perception of CA technology among small-holder farmers.

The study shows that the mean percent of cultivated area covered under CA from the total cultivated land 38.58%., the area coverage is low farmers did not cover the whole cultivated land with CA technology practice due to constraints of mulch materials. The results of the study indicate that availability of mulch material is very important for the medium and high increment of crop productivity with CA technology practice. Conservation agriculture has proved its ability to reduced soil and land degradation and improve crop productivity in the study area. Besides, the study result shows the marginal probability of availability of mulch material has been used for crop production under CA technology 17% used very low availability of mulch material, 9% low and 4%medium. The study result indicated farmers have been used green manure and intercropping with low and very low crop residue materials. This result indicated among the three principles of CA technology practice (minimum soil disturbance, crop residue retention and crop rotations) farmers well practiced minimum soil disturbance and crop rotation. However less practiced of mulching due to less availability of crop residues mulch materials. This indicated there is challenging mulch materials due to free grazing, cattle released on crop land after harvest of crop and computed CA mulch materials which is decreased accessed to crop residue mulch materials. The study indicated accessibility of agricultural input such as fertilizers, improved seed and agrochemicals have significant influence on high and higher increment category of crop productivity with CA technology practice. On the other hand the study result shows farmers did not have access to improved farm equipment for CA technology practice. Farmers used only cultural materials of plough, sowing and harvesting. This implies that the application of CA technology practice to smallholder agricultural production situations requires some level of mechanization. The minimum-till seeding, weed control and cover crop management practices required specific mechanized processes. Access, availability and affordability of these mechanization options are importance for CA technology practice.

The summery statistics result shows that the mean frequency of extension advisory service by Development Agents (DA) visit per month mean 1.7, maximum 3 times and minimum 1 times per month. The key informant interview (experts from woreda and Kebele) explained the advisory services is not included multi discipline manner. There is limitation of integration of CA technology with farm implement mechanization of plowing, sowing and harvesting equipment Small-holder farmers used only cultural materials. This shows the extension advisory service did not introduced improved farm equipment for small holder farmers.

5.2. Recommendations

These results have important implications for CA technology practice, based on the study finding the following recommendations have been done. This study indicated there is challenging mulch materials due to free grazing. Cattle released on crop land after harvest of crop and computed CA mulch materials which is decreased accessed to crop residue mulch materials. This implies that reducing the competition between animal feed and soil mulch by increasing biomass production of crop residues without grain yield reduction. Hence this result indicated that there should be production of more biomass to meet the competing residue use for soil fertility and feeding livestock. In addition, the introduction of alternative feed sources is vital to reduce the pressure on residue use as livestock feed and to increase the proportion of residue retained on farmland as soil mulch.

The study result shows the extension advisory services is not included multi discipline manner for example small- holder farmer did not get agricultural mechanization or farm equipment advisory services. To create CA technology demand and to improve farmer's decision and technology selection enhancing institutional linkages between Research, Extension and farmer is important for CA technology practice. To scale up CA technology practice as site and farmer-circumstance specific it should take into consideration of the development of multi-stakeholder "innovation networks" focused on adapting CA technology practice to local conditions. Thus the socio economic and institutional factors at different level at national, regional, woreda, kebele and households should take in to consideration of variables affecting CA technology practice such as access to input, availability of mulch materials and site specific affordable mechanization for CA technology practice.

REFERENCES

2ACCA. (2018). Making Climate-Smart Agriculture Real in Africa with Conservation Agriculture Supporting the Malabo Declaration and Agenda 2063 Condensed Papers Book. Second Africa Congress on Conservation Agriculture, 279.

Abebe, A., Bedadi, B., & Bekele, A. (2020). Journal of Earth and Environmental Review on Conservation Agriculture in Ethiopia : Status of Application, Opportunities and Challenges. 2(3), 1–11.

Agajie, Mesfin, Getu, Aemiro, L. and T. (2004). Socio-Economic Assessment of Production and Utilization of Crop Residues in the Central Highlands Socio- Economic Assessment of Production and Utilization. https://doi.org/10.13140/ RG.2.2.19488. 40967

Agriculture, C. (2009). Annex 2 Case study Conservation Agriculture. (April).

Alemayehu, G., Shibabaw, A., Adgo, E., Asch, F., & Freyer, B. (2020a). Cogent Food & Agriculture Crop rotation and organic matter application restore soil health and productivity of degraded highland crop farms in northwest Ethiopia Crop rotation and organic matter application restore soil health and productivity of degraded. Cogent Food & Agriculture, 6(1). https://doi.org/10.1080/23311932. 2020.1831124

Alemayehu, G., Shibabaw, A., Adgo, E., Asch, F., & Freyer, B. (2020b). Crop rotation and organic matter application restore soil health and productivity of degraded highland crop farms in northwest Ethiopia. Cogent Food & Agriculture, 6(1). https://doi.org/10.1080/23311932.2020.1831124

Baudron, F., Jaleta, M., Okitoi, O., & Tegegn, A. (2014). Conservation agriculture in African mixed crop-livestock systems: Expanding the niche. Agriculture, Ecosystems and Environment, 187, 171–182. https://doi.org/10.1016/ j.agee. 2013.08.020

Bhan, S., & Behera, U. K. (2014). Conservation agriculture in India – Problems, prospects and policy issues 1 Introduction 2 Conservation agriculture definition and goals. 2(4), 1–12.

Habtamu Mengistu. (2018). Research Article Competitive Uses of Crop Residues Are Challenging Soil Fertility Management In Ethiopia

Bruce, 2011. (2013). Journal of Chemical Information and Modeling, 53(9), 1689–1699. https://doi.org/10.1017/CBO9781107415324.004

Does conservation agriculture change labour requirements ? Evidence of sustainable intensification in Sub-Saharan Africa. (2018). (35).

EATA. (2015). GTP2 and the Agricultural Transformation Agenda. FDRE. (2019). Federal Democratic Republic of Ethiopia Volume I : Main

Text:Growth and Transformation Plan II (GTP II) (2015/16-2019/20) Volume. I(Gtp II). Retrieved from https://ethiopia.un.org/en/15231-growth-and- transformation-plan-ii

Giller, K. E., Witter, E., Corbeels, M., & Tittonell, P. (2009). Conservation agriculture and smallholder farming in Africa: The heretics' view. Field Crops Research, 114(1), 23–34. https://doi.org/10.1016/j.fcr.2009.06.017

González-Sánchez, E. J., Mkomwa, S., Conway, G., Kassam, A., Fernández, R. O.-, Moreno-García, Carbonell-Bojollo, R. M. (2018). Making Climate Change Mitigation and Adaptability real in Africa with Conservation Agriculture. https://doi.org/DOI: http://dx.doi.org/10.13140/RG.2.2.32722.20161

Hachiboola, P. (2016). Gender Mainstreaming in Conservation Agriculture: Lessons from Conservation Agriculture Programme II in Mapanza, Southern Zambia. 67.

Hobbs, P. R., Sayre, K., & Gupta, R. (2008). The role of conservation agriculture in sustainable agriculture. Philosophical Transactions of the Royal Society B: Biological Sciences. https://doi.org/10.1098/rstb.2007.2169

Jirata, M., Grey, S., & Kilawe, E. (2016). Ethiopia Climate-Smart Agriculture Scoping Study. Fao, Addis Abab, 54.

Joshi, P. K. (2011). Conservation agriculture: An overview. Indian Journal of Agricultural Economics, 66(1), 53–63.

Joskow, J., & Yamane, T. (1965). Statistics, an Introductory Analysis. Journal of the American Statistical Association, 60(310), 678. https://doi.org/ 10.2307/ 2282703

Kassam, A., Friedrich, T., & Derpsch, R. (2019). Global spread of Conservation Agriculture. International Journal of Environmental Studies, 76(1), 29–51. https://doi.org/10.1080/ 00207233.2018.1494927

Koohafkan, P., Altieri, M., & Initiative, G. (2011). A methodological framework for the dynamic conservation of agricultural heritage systems.(FAO) of the United Nations, Rome, Italy. Retrieved from http://www.fao.org/fileadmin/templates/giahs/PDF/ Draft_Framework_GIAHS Dynamic Conservation.pdf

Kourilsky, P. (2009). Field Actions Science Reports. Field Actions Science Reports

The Journal of Field Actions, 7, 0–12.

Leye, M. T. (2007). Conservation tillage systems and water productivity - implications for smallholder farmers in semi-arid Ethiopia. Conservation Tillage Systems and Water Productivity - Implications for Smallholder Farmers in Semi-Arid Ethiopia, 1–117.

Moti Jaleta, Menale Kassie, and B. S. (2012). Tradeoffs in Crop Residue Utilization in Mixed Crop-Livestock Systems and Implications for Conservation Agriculture and Sustainable Land Management. Selected Paper Prepared for Presentation at the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz Do Iguacu, Brazil, 18-24 August, 2012, 18–24.

Peron, A. (2018). www.econstor.eu: Theoretical conception of climate- smart agriculture, Working Papers of Agricultural Policy, No. WP2018-02, University of Kiel, Department of Agricultural Economics, Chair of Agricultural Policy, Kie

Pretty, J. (2014). The spread of Conservation Agriculture: policy and institutional support for adoption and uptake. Field Actions Science Reports, 7(December), 0– 12

Sayre, K., & Govaerts, B. (2006). Chapter 15 : The principles of conservation agriculture. 164–174.

Schmidt, E., & Bekele, F. (2016). Rural youth and employment in Ethiopia. (December), 2016

Sci, J. A., & Res, F. (2018). Journal of Agricultural Science and A Review on Factors Affecting Adoption of Agricultural New Technologies in Ethiopia. 9(3).

Spielman, D. J., Mekonnen, D. K., & Alemu, D. (2013). Seed, fertilizer, and agricultural extension in Ethiopia. In Food and Agriculture in Ethiopia: Progress and Policy Challenges (Vol. 9780812208). https://doi.org /10.9783/ 9780812208610.84

Tekle, A. T. (2016). Adaptation and Constraints of Conservation Agriculture. 6(1), 1– 14.

Teshome, A., de Graaff, J., & Stroosnijder, L. (2014). Evaluation of soil and water conservation practices in the north-western Ethiopian highlands using multi- criteria analysis. Frontiers in Environmental Science, 2(DEC), 1–13. https://doi.org/ 10.3389/fenvs.2014.00060

Thapa, B., Khanal, B. R., & Marahatta, S. (2019). Effect of conservation agriculture on yield and yield attributing properties of wheat. 9(2), 329–335.https://doi.org/10.15406/ apar.2019.09.00444

Tsegay, A., Kidane, A., Tesfay, G., & Kahsay, G. (2018). Reduced Tillage and Intercropping as a Means to Increase Yield and Financial Return in the Dry lands of Tigray, northern Ethiopia : A Case Study under Rainfed and Irrigation Conditions. 10(2), 221–239.

Tsigie, A., & Tesfaye, A. (2012). Evaluation of crop residue retention, compost and inorganic fertilizer application on barley productivity and soil chemical properties in the central Ethiopian Highlands. Ethiopian Journal of Agricultural Sciences, 22(1), 45-61–61.

Wekesah, F. M., Mutua, E. N., Izugbara, C. O., Wekesah, F. M., Mutua, E. N., Izugbara, C. O., & Mutua, E. N. (2019). Gender and conservation agriculture in sub- Saharan Africa : a systematic review review. 5903. https://doi.org/10.1080/14735903.2019.1567245.

ANNEX 1. Household Survey Questionnaire General Information

1.1. Name of peasant Association/kebele---

1.2. Name of respondent ------------------- -- Age---- ----sex (circle one**)** a) M b) F

1.3.Educational level of respondent? a) not read and write (b) read and write c) religious education d) grade one to grade two (e) grade three and above 1.4.Dominant livelihood option a) farming) b) non-farm c) off farm

1.5. Source of animal feed crop residue -----%, communal grazing land --%, cut and carry----% , grazing on crop land after harvest---% and factory and grain mail by product -----% , Cultivated land ha

1.6. From the total cultivated land how many ha of land covered with CA------------

1. Crop production and CA practices

1.1. When did you first hear about CA technology? In ______

1.2. Are you aware of Conservation Agriculture (CA)? a) Yes ( ) (b) No ( )

1.3. If „Yes" do you practice it? (a) Yes ( ) (b) No ( ). And if your answer is yes why did you decide to produce crops in CA practice? ---

1.4. Where do you practice your Conservation Agriculture knowledge? a) at your farm……………b) other peoples" farm……….

1.5. Did you discuss with your family before you practiced CA? a) Yes b) no. If your answer is no specify?---

1.6. What are the major crops produced in in CA practices 1. ----2. ---- 3. ----.4. ----5. --

1.7. The perception of farmer about Productivity of major crops with CA practice a) no difference of yield increment from conventional tillage b) medium yield increment c) high yield increment d) higher yield increment

1.8. In your opinion, what are the main differences between CA and the conventional way of farming? **---**

1.9. What kind of changes have the farmers already seen? Are they beneficial and in what way?---.------------------CA package practices among smallholder farmer

1.10. Indicate by putting a tick on appropriate answers in the corresponding table of the following CA practices

No	Conservation agricultural practices	yes	no
1	Reduced /minimum tillage		
2	Crop rotation		
3	Mulch		
3.1	grass mulch		
	crop residue		
	cover crop , inter crop, green manure		
4	compost and manure		

1.11. Are you practiced the three CA package or principles together a) yes b) no

If no would you please explain the reason-----------------------?

1.12. Frequency of tillage and weed in CA practices and conventional tillage

Major crop type	Soil type (sand, silt, clay)	Number of Tillage frequency		weed			
				Non CA		CA	
		non CA	CA	Number of weed frequency	Herbicides used	Number of weed frequency	Herbicides used

1.13. Are you using mulching a) yes b) no if your answer is yes what type of mulch do you used?-----------

1.14. Did Cover crops are maintained (mulch greater than 30%) a) yes b) no if your answer is no specify -------------------------------

1.15. Do you leave straw and use crop residue for CA after harvest a) yes b) no if no specify **---**

1.16. Do cattle released on CA crop land to graze freely crop residue after harvest a)yes b) no if yes specify how do you compensate the removal of this residues by cattle feeding **---------**

1.17. Did you practiced green manure in your CA farm a) yes b) no , if yes specify which type of crop used for green manure **--**

1.18. Did you practiced inter cropping a) yes b) no, if yes specify what type of crops used for inter cropping, a) major crop 1 with ------------ inter cropping b) major crop 2 with---- intercropping C) major crop 3 with------------intercropping

1.19. Did you practiced Crop rotation a) yes ( ) b) no ( ) if your answer is no explain the reason--If your answer is yes would you please specify the crops rotated? Frist season -------------- crop produced, second season crop produced, third crop.

Crop rotation practice of farmers a) not at all b) rarely used c) frequently d) more frequently

1.20. How do you manage your CA farm weed? Hand weeding b) herbicides c)both herbicide and hand weed

1.21. What type of inputs using in your CA crop production practice (tick on appropriate answers)? a) Inorganic fertilizer (NPS, Urea) b) organic (compost and manure) c) bio fertilizers d) herbicides and other chemicals

1.22. Did you use farm equipment's for CA practice a) yes b) no

If yes specify the type of farm equipment's? --

If no would you please specify the reason? -------------------------------------

1.23. 1.23. Did you practiced CA on the same plot of land every year a) yes b) no? if you say yes for how many year or cropping season did you practice CA in the same plot of land a) 1 year b) 2 years c) 3 years d) 4-6 years e) more than 7 if no specify the reason-----------------

1.24. Did you observe the yield increment in CA practice? a) Yes b) no. If yes in which year did you observe a) during the 1st year b) 2nd year c) 3rd year d) 4-6 years e) over 7 years

1.25. During the past 3-5 years did you observe in your area rainfall irregularity in terms of onset, dry spells and early cessation? Yes b) no if yes how did you compare CA practice and crop production during this years? ----------------------

2. Institutional factors extension services

2.1. Did you get extension and advisory service on CA practices before? a) Yes b) No If yes who did give extension services a) government extension agents b) NGOs c) both

If no why? Specify --

If you got extension services how frequent were you visited by development agents last year a) Once per month b) twice per month c) 4 times per month d) others specify-

3. Institutional Factors (input and credit services)

3.1. Do you have any access to credit to finance your CA farming business a) Yes (b) No; If „yes" where did you access credit from? a) Bank ( ) (b) micro finance (c) Cooperatives and UNION (d) Others/specify ……………

3.2. What was the purpose of the credit acquired a) To buy fertilizers, agrochemical and seed b) to by equipment c) Others/specify……………………

3.3. Who supply input a) UNION b) primary cooperatives c) private sector

3.4. Do you always get inputs at the right time? A).Yes b) .No; If no, what are the reasons? a) Unavailability b) Far distance c) Others (specify) ---

3.5. Do you always get inputs in the quantities that you need every year? a) Yes b).No If no, why? a) Not available b) too expensive c) Cash shortage d) I am not sure of benefits e) not available on time. How did you solve these problems? ------------------ ----------------------------------Challenge and benefits of CA

4. What are the most important benefits of CA? -------------------------------------

4.1. What are the most challenges of CA crop production practices? -------------

ANNEX 2. Focused group discussions for farmers

1. General information
2. Name of peasant Association/kebele---
3. Group number---------------------
4. Name of respondent

4.1.1. ------------------- --Age---- sex (circle one**)** a) M b) F educational level**-**

4.1.2. ------------------- Age---- sex (circle one**)** a) M b) F educational level

4.1.3. ------------------- Age---- sex (circle one**)** a) M b) F educational level

4.1.4. ------------------- Age--- sex (circle one**)** a) M b) F educational level**-**

4.1.5. ------------------- Age----sex (circle one**)** a) M b) F educational level**-** Educational level of respondent? a) Not read and write (b) read and write c) religious education d) grade one to grade two (e) grade three and above

5. When you did first introduced about CA in your locality?_______Year, who first introduced you about the CA
6. Do you think CA is suitable for you? a) Ye b) no If no specify -------------------
7. Did you discussed with your family when you planned to practice CA? a)yes b) no If no specify --
8. During the past 3-5 years did you observe in your area rainfall irregularity in terms of onset, dry spells and early cessation? Yes b) no if yes how did you compare CA practice and crop production during this years and normal year? -------------
9. Have you ever been trained on CA by an extension officer/s either from government, Donors or other companies (If more than one, please tick both) a) Government b) NGO c) Other companies/Specify--------------
10. How often does extension officer pay a visit to the groups" farm?

    a) Once a week b) Twice a week c) Once a month d) Twice a month
11. Does the extension services help you in understanding CA better? a) Yes (b) No
12. Did you practice the CA package (three CA principles) in your farm a) yes b) no if no specify the reason?--
13. What was the % age contribution of the crop residue for livestock feed? __________% and for CA practice ----%?

14. At how much % did you cover your farm with mulch a) <30% b) > 30%

15. If the mulch cover < 30% what are the mechanisms to improve this ---------------

16. Did use any farm equipment's for CA practice? If they used what type of equipment's? And from where they get? If no specify? ------------------------

17. How many % of your farm land covered with CA?

18. If you are not cover the whole farm land I CA what is the reason

19. Do you know more or less labor in CA practices as compared to conventional tillage? Specify the reason--------------------------------------

20. what are the major problems hindering the CA implementation

a)…………………………………………… b) ------------------------------------

c) -- d) ------------------------------------

21. What do you think about the solutions to the above problems? ---------------------

ANNEX 3. Check list for key informant's interview

1) Name of respondent -------------------- sex --------age --------- organization ------

Mobile no -------------------- educational level -------------

2) When CA practiced did introduced in your area**? year----------**

3) Did you participated in CA training**?**

4) Did farmers practiced the three CA package together? a) Yes ----b) no; if you say no what is the reason?

5) During the past 3-5 years did you observe in your area rainfall irregularity in terms of onset, dry spells and early cessation? b) no; if yes how did you compare CA practice and crop production during this years and normal year? ------

6) Did farmers covered 100% their cultivated land with CA? yes/ no if no explain the main reason---

7) Is there any yield difference between CA and conventional practice? yes /no

8) The access of inputs for CA

Input type	Yes	No	If no explain the reason
Fertilizers			
Improved seed			
chemicals			
Improved farm equipment			

9) What is the problem hindering implementation of CA technologies in your area? ---

10) What are the possible solutions--

ANNEX 4. Sample rural kebele population and land use

Sample Rural kebele population, and land use			
Description	Unit	Rural kebele name	
		Chimbord	Yenebirina
Population	No	6,300	5,700
Male	No	3,121	2,861
Female	No	3,179	2,839
House hold	No	915	831
Male	No	813	735
Female	No	102	96
Crop (cultivated land	Ha	787.5	712.5
Forest land	Ha	21.675	57.75
grazing land	Ha	125.75	102.375
others	Ha	12	8
Areas covered with CA	Ha	308.25	298.75
Number of household practicing (using CA)	No	850	690
Male	No	695	615
Female	No	155	75
Number of farmers' Cooperative	No	1	1
number of FTC	No	1	1
Number of DA	No	5	5

Source: Chimbord and Yenbrina kebele Agriculture Development office.