Opportunities and Challenges for Adopting Conservation Agriculture at Smallholder Farmer's Level

The case of Emba Alage, Tigray, Northern Ethiopia

A THESIS

Submitted to Indira Gandhi National Open University in partial fulfilment of the requirements for the degree of Master of Arts in Rural Development

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DECLARATION

I, **Edries Mohammed Seid**hereby declare that the Dissertation entitled **— Opportunities and Challenges for Adopting Conservation Agriculture At Smallholder Farmer's Level, The case of Emba Alage, Tigray, Northern Ethiopia**", submitted by me for the partial fulfilment of the M.A in Rural development to Indira Gandhi National Open University, (IGNOU) new Delhi is my own original work and has not been submitted earlier either to IGNOU or to any other institution for the fulfilment of the requirement for any course of study. I also declare that no chapter of this manuscript in whole or in part is lifted and incorporated in this report from earlier work done by me or others.

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CERTIFICATION

This is to certify that Mr. **Edries Mohammed Seid** student of M.A (RD) from Indira Gandhi National Open University, New Delhi was working under my supervision and guidance for his project work for the course MRDP – 001. His project work entitled **— Opportunities and Challenges for Adopting Conservation Agriculture At Smallholder Farmer's Level, The case of Emba Alage, Tigray, Northern Ethiopia**", which he is submitting, is his genuine and original work.

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ABREVATIONS AND ACRONYMS

CA: Conservation Agriculture

CC: Climate Change

CRGE**:** Climate Resilient Green Economy

CT: Conservation Tillage

ESSP: Ethiopian Strategic Support Porgram

FAO: Food and Agriculture Organization

GCCA-E: Global Climate Change Alliance, Ethiopia

GDP**:** Gross Domestic Product

GHG: Green House Gas

HH: Household

MASL: Meter Above Sea Level

MDG: Millennium Development Goal

NAPA: National Adaptation Program of Action

NRC: National Research Council

RCT: Resource Conserving Technology

SLM: Sustainable Land Management

SWC: Soil and Water Conservation

UNFCCC: United Nations Framework Convention on Climate Change

ZT: Zero Tillage

ABSTRACT

It is a common practice for farmers in Tigray to graze or remove all crop residues from their fields after harvest. This practice leaves the soil bare and susceptible to water and wind erosion. The top fertile soil is eroded over time leaving unfertile and degraded soil for crop production. There is also ample evidence that the currently used methods to grow crops are destroying the land and undermining the future. Conservation agriculture (CA) is considered as a best alternative for the conventional farming.

Despite the obvious productivity, economic, environmental and social advantages and benefits of CA, adoption does not happen easily. There are good reasons for individual farmers not to adopt CA in her/his specific farm situation. The origin of the hurdles ranges from intellectual, social, financial, biophysical and technical, infrastructural to policy issues. Knowing the respective problems and challenges allows developing local specific viable strategies to overcome them.

This study assessed the actual technical and social issues in the ground in order to identify the challenges and opportunities for adopting CA at small holder farmer's level taking the case of Embalage Woreda. Embalage Woreda is purposely selected because the selected village farmers have some exposure to the partial practices of CA through a project. A total of 30 households about 20% selected from the village project participants.

The main challenges which hinder the adoption of conservation agriculture identified from the individual interview, focus group and key informant discussion are lack of knowledge in CA at expertise and farmers level; belief of farmers on tillage, technical, social, financial and policy issues. Similarly, the major opportunities sort out are crisis during drought, increasing environmental concerns, rising input costs like fertilizer, challenges of climate change and technical potential for improvement.

CHAPTER ONE

1. INTRODUCTION

1.1 Background

Declining soil fertility is a major constraint on crop production in the semi-arid highlands of Tigray, Northern Ethiopia. In many parts of Ethiopia, land degradation in the form of soil erosion, nutrient depletion, soil compaction, and increased salinization and acidity pose a serious threat to sustainable intensification and diversification of agricultural production systems. Moreover, prevailing soil management practices including over tillage and blanket fertilization are key factors in Ethiopian agriculture's contribution to climate change. It is estimated by the World Bank that annually, 30,000 ha of agricultural land is lost due to topsoil erosion, and that the annual cost of land degradation is about 2-3% of agricultural GDP. Furthermore, the rate of soil loss due to water erosion is among the highest globally, averaging 30 to 42 tons/ha/year,(Mitiku et al, 2006). In addition, Ethiopia has the highest level of salt affected soils in Africa (FAO, 1988),while the occurrence of highly weathered acid soils is two to three times higher than that of other East African countries (Sumner and Nobel, 2003) .[3]

One of the major constraints to crop production faced by smallholder subsistence farmers is the inadequate supply of nutrients (Quinones et al., 1998; Shapiro and Sanders, 1998). Farmers are either entirely abandoning the traditional practice of using natural fallow to restore soil fertility, or are unable to leave land fallow for long enough for it to be effective. The use of mineral fertilisers is declining as they are increasingly beyond the means of most small-scale farmers (Larson and Frisvold, 1996). Erosion and severe run-off are further depleting existing soil nutrient reserves, while levels of soil organic matter are declining as land is subject to over-use.

The majority of the soils of Tigray are reported to be shallow, have low soil fertility, high run-off, and low infiltration capacity (Mitiku, 1996). Declining soil fertility is particularly severe in Tigray because of high nutrient losses through soil erosion, and extremely low use of external nutrient inputs (Virgo and Munro, 1978).

Declining soil fertility has continued to be a major constraint to food production in many parts of the tropical region. The low soil fertility in the tropics has been attributed to the low inherent soil fertility, loss of nutrients through erosion and crop harvests and little or no addition of external inputs in the form of organic or inorganic fertilizers. This is particularly evident in the intensively cultivated areas, traditionally called high potential areas that are mainly concentrated in the highlands of Ethiopia.

These imply that the outflow of nutrients in most smallholder farms far exceeds inflows. To address the problems of soil fertility, several technological interventions, especially those geared towards nutrient management and soil moisture conservation, have been suggested. Besides, the productivity of some soils is constrained by some other limiting factors even though they have high potential productivity or are naturally fertile.

In many parts of Ethiopia, including Tigray, the shortage of firewood leads to the utilization of straw and leaves for fuel. Animal manure is also commonly dried and burned. Very little organic residues are therefore returned to the soil apart from the roots of annual crops. As a consequence, soils become low in organic matter after sometime of continuous cultivation. Depletion of organic matter and destruction of soil aggregates lead to increased rates of soil losses in cultivated areas.

However, they can be reversed in part by promoting increased adoption of appropriate soil management techniques and soil amendments by smallholder farmers as well as by restoring soil fertility through enhanced agronomic practices, improving the adoption of appropriate fertilizer use and other soil fertility augmenting technologies, such as conservation agriculture. Many countries that have successfully transformed their agriculture sector, and done so in a sustainable manner, have focused on the adoption of improved soil management techniques and other soil fertility enhancing technologies, with significant gains.

This research aims at understanding and documenting the opportunities and challenges for adopting conservation agriculture at smallholder farmer level in Tigray in the case of Alaje woreda and suggests policies and strategic approaches for increased adoption of the technology by smallholder farmers.

1.2 Statement of the problem

Conservation actions to halt and reverse degradation as well as boost agricultural productivity have gained increasing interest in Africa and the world at large. Conservation approaches, particularly through Conservation Agriculture (CA), could contribute significantly to reducing land degradation and increasing food security.

Conservation agriculture (CA) has been proposed as an alternative to conventional tillage to sustainably intensify crop production. Conservation Agriculture (CA) is a combination of tested scientific technologies and/or principles in agricultural production. The key-elements of conservation agriculture are minimal soil disturbance (minimum or no-tillage), stubble retention, and the implementation of viable crop rotations. Compared to tillage-based agriculture, CA has the potential to decrease soil loss, enhance levels of soil organic matter, increase plant available soil water, and save costs due to fewer or no tillage operations. CA is an approach that advocates the concept of sustainable intensification of production by picking the best possible options that farmers can apply at their own conditions.

The practice of CA in Africa is now maturing with increasing demand for more sustainable agricultural practices and better natural resources management and conservation. Conservation Agriculture, as a concept for natural resource-saving, strives to achieve acceptable profits with high and sustained production levels while concurrently conserving the environment. It appears to be a promising way of attaining sustainable agricultural production.

Conservation Agriculture is being practiced in a number of countries as traditional soil and water conservation practices by specific communities or at pilot project scale throughout the continent. Despite the difficulties faced in the first years of implementation, benefits from this practice have shown great potential in boosting agricultural production and diversifying livelihood incomes.

But its level of adoption is still very low and the total area of coverage could be estimated to be less than 1 percent of the continent’s land. Therefore, there is need to move from project based and site based approaches to programme large scale approaches through up-scaling of this technology.

The vulnerability to climate-related hazards and food insecurity is closely linked to land degradation. About 85% of the land surface in Ethiopia is considered susceptible to moderate or severe soil degradation and erosion. In the Highlands, those problems are reducing the sustainability of agricultural production, thereby making it difficult for rural populations to meet their basic needs. Repeated ploughing to achieve fine seedbeds using *maresha*, the almost complete removal of crop residues after the harvest and insufficient application of manure are major contributors for soil degradation in Ethiopia. Tillage has long been used by farmers to loosen the soil, make a seedbed, and control weeds. However, not all outcomes of this practice are positive; it has been discovered that tillage operations, over time, cause a decline in soil fertility and overall productivity resulting from deterioration of soils' physical, chemical, and biological properties.

Among the solutions being floated to mitigate the impact of climate change is adapting to droughts through sustainable farming methods. Conservation farming (CF) practices hold the promise of providing both a strategy for mitigating climate change and also working as an adaptive mechanism to cope with climate change. CF is being promoted as a panacea to the production challenges, confronting rural smallholder families particularly in Sub-Saharan Africa.

While soil conservation practices, including minimum or no tillage have long been practiced by farmers in Ethiopia, conservation agriculture and its associated package of best practices were introduced in 1998 by Sasakawa Global 2000 (SG 2000) on 77 maize plots (Matsumoto et al., 2004).

Despite the decade old national effort to systematically disseminate conservation agriculture, no empirical evidence has been presented as to what extent the technology package is being adopted, or the extent to which farm yields are being influenced. Only a few studies (Kassie et al., 2009; Rockstrom et al., 2009; Wellelo et al., 2009; and Shames, 2006) have reported on the status and effects of conservation agriculture in the country.

The adoption of CF in Ethiopia would enable farmers to benefit from improved crop yields and other associated economic gains and also contribute to the sustainable management of land resources in the country. Besides, the policy environment in the country is favourable for promoting CF as the government has recently developed a national strategy for Sustainable Land Management practices in which the CF is an important component. Despite such a sound policy framework, the practical implementation of the CF on the ground has not yet materialized.

Therefore, the adoption of CF, which aims to conserve soil and water by using surface cover (mulch) to minimize runoff and erosion and improve the conditions for plant establishment and growth could minimize the impact of climate change and land degradation in Ethiopia.

Looking in to the opportunities and challenges for adapting the conservation could enable to identify feasible strategies to promote and scale up conservation agriculture at a wider scale in smallholder farmers.

1.3 Research objective

1.3.1 General objective

The overall objective of this research is to identify the feasible strategies for the promotion and scaling up of conservation agriculture by smallholder farmers by studying the opportunities and challenges for adopting the tested technology.

1.3.2 Specific objectives

The research is specifically aimed at:

- To understand and analyse farmer's perception on elements of conservation agriculture;
- To document existing practices implemented by the farmers from components of conservation agriculture;
- To assess the opportunities and challenges for adapting the technology in the context of the existing farming system.

1.4 Research questions

The study answers the following research questions

- What is the farmer's perception on major principles of conservation agriculture?
- What are the current practices implemented by the farmers from components of conservation agriculture?
- What are the opportunities and challenges for adapting the technology in the context of the existing farming system?

1.5 Significance and scope of the study

The finding of this study will provide a first-hand information to government and non-governmental organizations about the current practices of CA, existing gaps, and opportunities for adoption of CA and also serves as a baseline for further study in the area of CA. These findings will be helpful for the bureau of agriculture and rural development in planning and decision making concerning CA in the future.

1.6 Organization of the paper

The thesis paper is organized in a way it addresses the objectives and hypothesis of the study and accordingly classified in to five main chapters.

The first chapter deals with introduction to the current status of conservation agriculture adoption efforts in the world, in Ethiopia and in Tigray region. Moreover, an attempt is made to describe the concepts of conservation agriculture and brief discussion on the so far efforts made to introduce the conservation agriculture in the region.

The second chapter deals with the review of relevant literatures throughout the world in the country and in the region.

The third chapter elaborates the research methodology which comprises the sampling procedures, socio-economic and biophysical description of the study areas, data collection and data processing methods employed by the study.

The fourth chapter focuses on the finding of the study and brief discussion of the major findings of the study in comparison with other relevant studies.

The fifth and last chapter deals with the concluding remarks of the study and recommendations to promote and scale up conservation agriculture at smallholder farmers level.

CHAPTER 2

2 REVIEW OF LITERATURES

2.1 Background of conservation agriculture

Reducing the intensity of tillage for economic reasons (leading to minimum tillage) or for environmental reasons (leading to conservation tillage and finally to zero tillage practices) is nota new idea. One of the first references in modern agriculture to no-till farming is probably Edward Faulkner's "Ploughman's Folly" (1945). Over the last few decades the practice of minimum and no-tillage had its ups and downs. In some situations it worked well, in others less well. Minimum tillage, conservation tillage and zero tillage were all applied as practices within conventional concepts of agriculture and therefore were not universally applicable. However, there appears to exist evidence that no-tillage can be successfully incorporated into a new concept of truly sustainable agriculture. In this case not tilling the soil mechanically becomes one underlying principle of a completely new understanding of agriculture. This concept shows in at least one world region over the last decade a consistent and exponential adoption curve.

During the last few years it is, under the name of Conservation Agriculture (CA), gaining popularity all over the world (Derpsch, 2001).Conservation Agriculture might well base on old, well known principles. But it combines these principles in a new way achieving synergies which had not been considered in the past and which only recently are being understood and investigated. The main objective in Conservation Agriculture changes towards providing a favourable microclimate for soil life by protecting the soil surface from sun, rain and wind as well as providing feed for the soil micro and macro-organisms. These organisms forming the soil life in CA are substituting biological tillage for mechanical tillage. While conventional agriculture is "cultivating the land", using science and technology to dominate nature, conservation agriculture tries to "least interfere" with natural processes. Similar thoughts have been developed over the past 50 years also in the Far East byMa sanobu Fukuoka (1975). While Fukuoka rejects even mechanization, this extreme is not justifiable in view of the requirements of modern agricultural production. But the approach naturally has implications for the required engineering interventions in agriculture and as such in the technical solutions offered.

During the last decade Conservation Agriculture (CA) has been gaining popularity all over the world. It is now applied on about 95 million hectares (Derpsch, 2005). Together with other organizations and stakeholders FAO has been promoting and introducing CA in several countries in Latin America, Africa and Asia. Applying these three principles conservation agriculture has been adapted to different climatic conditions from the equatorial tropics to the vicinity of the polar circle and to different crops and cropping systems, including vegetables, root crops and paddy rice. Today conservation agriculture in its different applications is increasingly seen as a way to practice sustainable agriculture. It is becoming increasingly popular where conventional agriculture is facing serious problems due to land degradation and increasingly unreliable climatic conditions. In this way it is becoming also a popular concept in rehabilitation responses to emergencies caused by natural disasters.

The key element which CA is focussing on is soil organic matter which stabilizes soil and increases water holding capacity. This particular characteristic makes CA so important particularly for dry lands. Water is one of the most precious natural resources for agricultural production. Agriculture accounts for 70 % of the actual water use (FAO, 2002). The predictions are that by 2025 the water consumption will exceed the available "blue water" if the current trends continue (Ragab & Prudhomme, 2002). In the Indian state of Punjab, characterized by intensive irrigated agriculture, the ground water table is falling at a rate of 0.7 m per year(Aulakh, 2005). The decline of fresh water resources is not only due to increased consumption, but also due to a careless management of this precious resource. Agriculture is part of the problem by wasting water and by sealing and compacting the soils so that the excess water cannot anymore infiltrate and recharge the aquifer. Increasing numbers of flood catastrophes are one symptom of this (DBU, 2002). Especially in those world regions, where water is already now the limiting factor for agricultural production, this wasteful practice is threatening the sustainability of agriculture. Rising temperatures and evapo-transpiration rates combined with more erratic rainfall aggravate the water problems in rain fed agriculture (Met Office, 2005).

Soil does not only impact on production, but has also an influence on the management of other natural resources, such as water. Soil structure is strongly correlated to the organic matter content and to the soil life. Organic matter stabilizes soil aggregates, provides feed to soil life and acts as a sponge for soil water. With intensive tillage based agriculture, the organic matter of soil is steadily decreasing, leading first to a decline in productivity, later to the visible signs of degradation and finally to desertification (Shaxson & Barber, 2003). The lack of yield response to high fertilizer dose in the Indo-Gangetic Plains can be attributed to deteriorated soil health as a result of over exploitation (Aulakh, 2005). In the Indian states of Uttaranchal or Haryana the organic carbon content in soils reaches minimum values below 0.1 % (PDCSR, 2005).

Agricultural production has all over the world led to soil degradation, more pronounced in tropical regions, but also in moderate climatic zones. The world map of degraded soils indicates that nearly all agricultural lands show some levels of soil degradation (FAO, 2000).

The current concept of Conservation Agriculture (CA) has been mainly shaped in the subtropical Brazilian large-scale market oriented farming conditions. While different authors have proposed different definitions, a definition largely used is that proposed by FAO:

"CA is a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. CA is based on enhancing natural biological processes above and below the ground. Interventions such as mechanical soil tillage are reduced to an absolute minimum, and the use of external inputs such as agrochemicals and nutrients of mineral or organic origin are applied at an optimum level and in a way and quantity that does not interfere with, or disrupt, the biological processes".

From this definition, one can infer that conservation agriculture is not an actual technology; rather, it refers to a wide array of specific technologies that are based on applying one or more of what are widely regarded as the three main conservation agriculture "principles" (IIRR and ACT, 2005):

- Reduce the soil tillage, or suppress it altogether;
- Cover the soil surface adequately—if possible completely and continuously throughout the year;
- Diversify crop rotations.

In the international literature, terms such as conservation tillage (CT), zero-tillage (ZT), direct drilling (DD), direct sowing/seeding (DS), and Resource Conserving Technologies (RCTs) are also common, and usually refer to technologies or technology packages that may constitute specific subtypes of CA systems or intermediate systems. One can mention that CA frontiers with other technologies such as agroforestry, or soil and water conservation practices (SWC) such as terraces, zaï, half-moon and other water harvesting practices are still not precise.

Whatever the label actually used, there is growing evidence of large-scale adoption of CA systems worldwide (Derpsch, 2005). However, the type of actual CA practices used in diverse agro-ecological and socio-economic environments is highly variable, and frequently departs from the simultaneous and rigorous local application of the three generic CA principles (Erenstein, 2003; Harrington and Erenstein, 2005; Lahmar et al., 2007b). Only in limited areas are such principles applied simultaneously and consistently over time: such cases that one may call ‘full conservation agriculture’ are common, yet not systematic, in southern Brazil (do Prado, 2004; Bolliger et al. 2006) and a few other Latin American countries (Scopel et al. 2004; Ribeiro et al. 2007).

Historically, CA practices and systems emerged as a response to soil erosion and profitability crises in USA, Brazil, Argentina and Australia (Coughenour, 2000; Scopel et al., 2004) . Their development was allowed by the discovery and availability of herbicides, which for the first time gave farmers a practical and economic option to control weeds other than by agronomic and mechanical means. The transition from conventional plough-based agriculture to conservation agriculture was neither fast nor without hurdles: in most places, it took several decades of hard work and trial-and error by a variety of actorsto get to the point where CA systems were profitable and adapted to the specific local conditions that each user had to face.

Today, CA in its many forms covers about 100 million ha worldwide (Derpsch, 2005), versus 60 million in 2000 (Derpsch, 2001). This swift increase in acreage touches continents and countries very differently: CA occupies a large share of areas devoted to annual crops in the USA, Australia, Brazil and Argentina, but remains marginal in Europe (de Tourdonnet et al., 2007) and in Africa 124 R. Lahmar and B. Triomphe and in Africa (Harrington and Erenstein, 2005). In Asia, a swift increase of CA surfaces is occurring in the Indo-Gangetic plains (Gupta et al., 2007). In China and Central Asia, current CA acreage is expected to increase rapidly due to the growing interest in CA, existing favorable institutional and policy conditions, the involvement of machinery manufactures and national and international research institutions (Harrington and Erenstein, 2005). In most cases, farmers who have adopted CA until now are motorized and practice large-scale commercial, high-input, market-oriented agriculture on hundreds
or even thousands of hectares. They usually have access to strong support services, including research, extension, input supply and credit. Furthermore, much of the adoption has occurred under favourable agro-climatic conditions: deep soils, humid or sub-humid climates in particular.
Conversely, adoption of CA by smallholders in unfavourable areas has been the exception. Such differential adoption rates raise a number of questions, be it relative to the universal validity of the CA principles, or relative to the factors and conditions involved in the adaptation and adoption process.

The objective of this study was to identify the potential benefits and challenges related to the application of CA experiences for the dry areas of the Arab region. It will also address a number of questions by drawing on recent international experiences with CA in diverse environments.
As for the main sources used for this paper, there is increasing evidence available worldwide about the many past and on-going experiences with CA, as reported for example during the first three World Congresses on Conservation Agriculture, held respectively in Madrid-Spain in 2001 (Garcia-Torres et al., 2001), in Foz de Iguassu-Brazil in 2003, and in Nairobi- Kenya in 2005. Yet little of this evidence has been systematized, and hence it is difficult to draw synthetic lessons. Also, the latest results of many on-going experiences have not been reported to the worldwide CA community.

Fortunately, the results of the EU-sponsored KASSA project (Knowledge Assessment and Sharing on Sustainable Agriculture) are now available: it had the specific objective of synthesizing the validated scientific knowledge generated on CA in a number of regions: Northern and Eastern Europe, the Mediterranean, Latin America and Asia (Lahmar et al., 2007a). Other key sources for this paper are the results of a series of case studies conducted within the framework of collaboration between FAO and CIRAD (Triomphe et al., 2007a; Boahen et al., 2007, Baudron et al., 2007, Nyende et al., 2007; Kaumbutho and Kienzle, 2007, Shetto and Owenya, 2007). In addition, a number of reviews and syntheses about CA have also become recently available, such as West and Post (2002), do Prado (2004), Scopel et al. (2004), IIRR (2005), ACT (2005), and Bolliger et al. (2006). Finally, first-hand knowledge and contacts with many on-going CA projects were also extensively used to complete the picture whenever necessary.

2.2 Agricultural Productivity and profitability of CA

CA is widely heralded for its effect on crop productivity. Yet they are far from uniform. In Latin America, crop yield increases at the farm level when comparing NT systems to conventional plough-based systems were extensively reported (Ribeiro et al., 2007a). Conversely, in Northern Europe and the Mediterranean, CA does not appear to drastically change yields (deTourdonnet et al., 2007a, Arrúe et al., 2007a). On average, yields in Northern Europe on poor and medium fertile soils do not change (+/- 10%) under CA; they actually decrease slightly on very fertile soils with a high intensive level of production. In the Mediterranean countries, most of the Conservation Agriculture for Sustainable Land Management 125studies carried out in Spain and in Morocco concluded that yields are generally 10-15% higher under no-tillage, especially in dry years. Similar observations have been reported in LatinAmerica (Ribeiro et al., 2007b): yield effect tends to be stronger during relatively dry years, while productivity among contrasting management systems remains similar under normal climatic conditions. This makes CA a more interesting option in dry areas where drought is a continual hazard. The effect of CA practices on productivity is not uniform however, as different annual grain crops respond differently to different soil / tillage systems: the crop rotation increases and stabilizes yield more than continuous cropping.

In terms of profitability, large-scale farmers in Latin America and Europe gain significantly from using CA, due mostly to lower mechanization / motorization costs, including reduction in labor, fuel, lubricants, and maintenance and depreciation costs of agricultural machinery. A tractor lasts three to four years longer in NT systems than when used for hard tasks such as ploughing in conventional cropping systems. Savings allow increasing crop area and more efficient use of machinery and labor force. Small-farmers who depend on use or access to a tractor also benefit directly or indirectly from reduced machinery costs, and also from more autonomy from hired machinery entrepreneurs (Scopel et al., 2005). In Asia, savings ranging from US$ 70 to 140 per hectare accrue from a combination of less needs for irrigation (from 15-20% or even more under bed planting), and increased yields of 200-500 kg/ha.

While cost reductions are most common with the use of CA, savings may be offset by additional costs incurred for chemical weed and pest control. It is reasonably arguable that the rise of the cost of pesticides and/or heavy infestations of weeds, pests and diseases may affect farmers' decision with respect to the use of CA.

In small-scale farming throughout Latin America and Africa, CA reduces drudgery, especially for farmers depending on animal draught or human labor. Reduction in total labor use ranges from 11%to 46% depending on the crops grown. Reduction in labor peaks throughout the agricultural year is also an important aspect. Labor reduction allows farmers to increase their cultivated area or to undertake other activities generating additional incomes, or even to provide help for their neighbours, which is also socially relevant (Ribeiro et al., 2007b).

The short term socio-economic benefits that CA provides through the reduction of costs of production, the need to improve farms' competitiveness, the current trend of increase of the farm size, market globalization and the steady increase of fuel cost are seen likely sufficient to boost CA systems within Europe and possibly overcome farmers and societal reluctance due to sociocultural barriers or environmental considerations. In many European regions the shift from conventional agriculture to CA is likely already ongoing (Lahmar et al., 2006).

Long-term socio-economic benefits are supposed to come about with the improvement of soil physical, chemical, and biological properties and soil fertility (Gupta et al., 2007a-b) which may also increase the profitability and attractiveness of CA. However, a recent study (Deen et al., 2006) showed that a change in yields occurs in the early years of NT adoption; the length of time under NT had a minimal impact on crop yield response to the NT system.

Taken together, these results show clearly that RT and especially NT greatly cut production costs in basically all types of agro-ecosystems. The increased global and regional competition will certainly urge more farmers to seek a reduction of their production costs and an increase of their productivity and profitability. CA has proven to be an effective means to achieve these goals. However, the magnitude of the increased profitability depends on many factors including soil, crop, rotation, machinery, cropping and farming systems, etc. Unfortunately, reliable long-term data related to input costs, and to socio-economic aspects of CA, remain scarce and do not allow drawing a comprehensive picture and a realistic comparison among countries, cropping systems, and farming conditions (Lahmar et al., 2006).

2.3 CA for soil and water conservation in dry areas

Changes induced by CA practices in soil properties related to soil water, fertility and erosion, and the erosion processes as affected by CA practices have been researched in many dry areas. Most of the studies were conducted at research stations, on a limited number of soil types and only few studies refer to long-term experiments or to on-farm designs. Number of properties have been investigated (soil structure and porosity; aggregates stability; soil infiltration and hydraulic conductivity; soil compaction; earthworm population; soil organic matter (SOM) and carbon (SOC)) but the studies rarely addressed all the properties simultaneously. This makes it difficult to understand the functioning of CA systems and to build a comprehensive knowledge base regarding the long-term impact of CA systems on soil and water in dry land agro-ecosystems. In this section we will focus mainly on research results obtained in the Mediterranean dry lands (Arrúe et al., 2007b).

2.4 Soil moisture conservation

Soil structure and porosity change when soil management shifts from tillage to RT or NT and soil cover. However, the magnitude and the significance of the changes seem to vary depending on soil texture, the climate, and the CA practice, i.e., RT or NT and the soil cover management. In many situations CA practices led to compaction of the topsoil (Gómez et al., 1999; Hernanz et al., 2002)and a decrease of soil porosity (Lampurlanés and Cantero-Martínez, 2006). As consequence, the hydraulic conductivity decreases (Lampurlanés and Cantero-Martínez, 2006; Moret and Arrúe,2007). The negative effect of NT on infiltration can be counteracted by the presence of residues onthe soil surface, resulting in lower evapo-transpiration and greater water storage in the upper soillayer (Josa and Hereter, 2005; Lampurlanés and Cantero-Martínez, 2006), or by the increase in the population of earthworms, resulting in a greater number of vertical paths created by continuous worm burrows that maintain or increase hydraulic conductivity (Moreno et al., 1997). However, in the Mediterranean context, soil moisture as influenced by climatic conditions of the year is a determinant factor for the number of the earthworms during and between years (Ojeda et al., 1997).

2.5 Soil fertility improvement

Changes in SOM and SOC under CA are intensively reported in the international literature. SOC generally increases, and the increase rate depends on the CA practices and the crop rotations (Westand Post, 2002).

NT systems always accumulate more organic matter on the soil surface than RT systems. One particular feature of CA is that SOC accumulates near the surface of the topsoil which leads to a vertical stratification of the carbon (Hernanz et al., 2002; Moreno et al., 2006; Mrabet, 2002; Álvaro-Fuentes et al., 2007). This distribution of SOM and SOC improves the biological activity, enhances the physical properties of the topsoil, and reduces erosion risk.

Soil surface crusting is very common in dry areas. It plays a key role in runoff and erosion. Low aggregate stability favours soil surface sealing and erosion (Lahmar and Ruellan, 2007). CA practices seem to improve aggregate stability (Mrabet et al., 2001): the improvement is higher in NT systems compared to RT systems (Hernanz et al., 2002). The increase of aggregate stability is correlated to the increase of SOC (Hernanz et al., 2002). Nevertheless, soil sealing is a complex process Conservation Agriculture for Sustainable Land Management 127128 R. Lahmar and B.

Triomphe involving many factors and in regions where crusting is a significant problem, soil cover plays a key role in preventing crust formation (Usón and Poch, 2000).

2.6 Contributions to erosion mitigation

Research focused on both water and wind erosion. Water erosion has been studied in annual crops in Spain (De Alba et al., 2001) and in perennial crops in Spain, Italy and Greece (olive orchards) (Gómez et al., 1999, 2005). Wind erosion has been studied in semiarid Spanish cereal/fallow lands (López et al., 2001; López and Arrúe, 2005). In Andalusia several studies focused on the development of simulation models and expert systems to predict the effect of tillage systems on water erosion under different climatic conditions and to design site-specific agricultural implements (Simota et al., 2005; De la Rosa et al., 2005). As results, in dry land olive crops, reduced tillage and soil cover seem to be effective in reducing water erosion (Dela Rosa et al., 2005). In cereal/fallow lands, reduced tillage, with chiselling as primary tillage, could be a viable alternative to mouldboard ploughing for wind erosion control (López et al.,1998, 2000).

From these results, it is very clear that the combination of soil cover and NT or RT plays a key role in controlling water runoff. However, it is not yet clear to what extent CA systems can mitigate soil erosion under the aggressive Mediterranean climate. Empirical observations and actual measurements of the drastic reduction of soil erosion by NT practices in Brazil led to the general thought that NT systems by themselves were strong enough to control erosion.

Consequently, farmers neglected complementary conservation practices and eliminated terracing systems. Recent results showed that the protection of soil surface by crop residues in NTsystems is not always followed by a reduction of runoff. In addition to leaching of nutrients and pesticides, sheet and rill erosion developed even on sites where NT systems have been used for along time. A new conservation technique, called "vertical mulching" (Denardin et al., 2005) is being developed in southern Brazil in NT systems. The combination of NT, terraces and tree plantations in northern Catalonia-Spain seem to be the best way to preserve soil, water and the landscapes.

2.7 Adaptation and dissemination of CA

As already highlighted, the shift to CA practices has historically largely been driven by economic considerations such as decreasing production costs, and especially the cost savings associated with the reduced use of machinery. This has been the case in Europe, in the U.S., and recently in the Indo-Gangetic Plains (Soane and Ball, 1998; Coughenour, 2000; Gupta et al., 2007b). Other factors which also relate broadly with economic factors include decreasing work load especially during seasonal peaks. To a large extent, ecological crises are a driver for CA adoption. Examples are the extreme erosion affecting Southern Brazil, and the complex agro-environmental sustainability crisis affecting the dominant intensive rice-wheat irrigated cropping systems of the Indo-Gangetic Plains. These were perceived and acted upon mostly because of their direct economic consequences in terms of the threat they posed to farmers' livelihoods, even though of late, environmental concerns and the perceived role of CA in achieving a more harmonious relationship with nature have become more prominent.

But the road to CA adoption is not straightforward. In many places, unforeseen technical problems drove many initial adopters back to conventional farming. This has, for example, been the case in Europe and the Mediterranean because of problems with weeds, pests, and crop residue management (Rasmussen, 1999; Arrúe et al., 2007b), or to excessive topsoil compaction (Munkholm et al.,2003). Lack of knowledge and technical advice (or access to them) has also discouraged farmers from adopting CA in many cases. Changes in economic circumstances have also had a large influence on adoption. In France, for example, the attractiveness of CA to farmers has been highly dependent on the types and amounts of subsidies in place under the Common Agricultural Policy which have fluctuated over time. In the Indo-Gangetic Plains, the retention of soil cover is still difficult because of the demand for crop residue for cooking fuel and animal feed is high in the region and many farmers are use to burning rice residue in the field to enable timely sowing a wheat crop.

More generally, the use of a cover crop and diversified crop rotations is still hardly practiced in many places due to climate and soil limitations, lack of adapted cover crop varieties, difficult management of crop residue in wet and dry conditions, competition for crop residue, and general market conditions. In turn, the difficulty of introducing cover crops means that farmers are often left to opt for chemical control under CA as the only alternative to ploughing if they do not have the labor resources necessary to control aggressive weed growth. This is especially true in manual agriculture in Africa (Boahen, 2007; Baudron et al., 2007).

Such difficulties may explain why some farmers around the world return partly or entirely to ploughing after years of practicing CA, even though they perceive the effectiveness of CA practices in increasing soil organic matter, enhancing earthworm activity, reducing soil erosion, and improving water infiltration and productivity under dry conditions. In the absence of systematic, unbiased monitoring of actual CA practices, and notwithstanding available estimates, the true current extent and type of CA adoption remain unclear. It seems, however, that RT is more common than NT in many places, and that areas listed as NT may correspond to fields managed in NT only for a part of the rotation, whereas the other crops of the rotation are managed using RT or ploughing. Such is, for example, the case of CA adoption in the Indo-Gangetic Plains (Gupta et al., 2007a), or in man-years across Europe (de Tourdonnet et al., 2007). Said differently, diverse tillage practices may follow one another in time and may coexist within the same farmland, as illustrated by the situation of small farmers in Southern Brazil, who while claiming to practice NT, resort periodically to tillage to handle difficult situations with respect to weed infestations, soil compaction or simply to incorporate lime (Ribeiro et al., 2005, Bolliger et al., 2006, Triomphe et al., 2007b).

2.8 Constraints for CA adoption

Process-wise, adoption seems to depend a lot on who is involved in the adaptation and dissemination process, and especially the role played by farmers and their organizations in leading multiple stakeholder consortia. Southern Brazil is well known for the fact that large-scale farmers and their associations have been at the forefront of CA adaptation and diffusion (through farmers' groups such as the Clubes da Minhoca, or Earthworm clubs) since the 1970s, taking advantage initially of experiences and NT equipment imported from the U.S. in the 1970s (Ekboir, 2003). The adoption process was catalyzed by a close interaction and collaboration among a number of stakeholders, including farmers, input and equipment manufacturers, local governments, and to a lesser degree, research and extension services. Many of the same dynamics are true for the large-scale farmers of Argentina, under the leadership of AAPRESID, a farmer-led society. In their case, CA adoption was strongly facilitated by the seemingly perfect fit between CA and the introduction of genetically-modified crops highly suited to management under NT, such as the "Round-up ready" soybean varieties.

Similar dynamics are at play at a more modest scale in the CA adoption processes observed elsewhere. In the Indo Gangetic Plains (Gupta et al., 2007), researchers and their partners developed and disseminated in a participatory manner a wide basket of Resources Conserving Technologies (7)(RTCs), as a result of the emergence and consolidation over 2 decades of continuous efforts of an effective and dynamic innovation system assembling efforts of public and private sectors, national and international research institutions, extension services and innovative farmers. In France, farmers, initially discouraged by the lack of interest of formal research, created their own associations, such as BASE(8) and FNACS(9) to exchange, develop and promote CA practices suited to their conditions(Triomphe et al., 2007b). Today, many more stakeholders and formal institutions have joined the on-going efforts, including research. Spain is the country with the longest experience with CA around the Mediterranean. The true development of CA practices began in earnest in the 1980swith the involvement of technical advisers from agricultural services, farmers' cooperatives and multinational and national companies and scientists, many years after the initial efforts to introduce CA were made. Nowadays, across Spain there are many research groups on CA organized within the Spanish conservation tillage research network, collaborating with many farmers' societies and consortia and developing basic and applied research linked to farmers' concerns including long-term experiments to develop and assess CA-based systems. It is worth mentioning that the first world congress on CA took place in Madrid in 2001 (García-Torres et al., 2001) and the third Mediterranean meeting on no-tillage took place in Zaragoza in 2006 (Arrúe and Cantero-Martínez,2006). In Italy, no-tillage trials started in 1968, but CA expansion began only in the 1990s. It was driven by the need to reduce cropping costs and the availability on the Italian market of sowing equipment and adequate herbicides (De Vita et al., 2006). In Tunisia adoption has increased markedly, as a result of collaboration between mostly educated large-scale farmers, a Tunisian high education and research school, the Tunisian Technical Center for Cereals (CTC), equipment manufacturers and providers under the auspices of an externally-funded project (Ben-Salem et al., 2006).Conversely, in Morocco, despite more than 20 years of successful CA research (Mrabet, 2007),farmers' adoption of CA practices remains still incipient, most probably due to the fact that the CA agenda has for the most part remained a research agenda, with no or weak linkages with farmers and other stakeholders.

While large-scale farmers, easily able to take risks in investing resources and to enrol allies, haveadopted CA relatively swiftly to the point where conventional farming has almost disappeared.

Adoption by small-scale farmers has been a much more tedious and delayed process. When it occurred, it was the result of systematic, well-funded, wide-ranging public efforts aiming at CA development. Such has been the case in Southern Brazil, within the context of the well-funded micro-watershed projects implemented in Parana and Santa Catarina States (do Prado, 2004; Bolliger et al.,2006). Research has been pivotal in the development of animal-drawn and manual CA equipment (Ribeiro et al., 2007a), a condition which was also key in the Andean valleys of Bolivia (Wall et al.,2003), and has recently been observed throughout Eastern and Southern Africa (Shetto and Owenya,2007; Baudron et al., 2007). Developing or making CA equipment available to farmers is indeed critical, as availability of jab planters, NT drills, herbicide sprayers and “knife-rollers” induce huge reductions in labour requirements and drudgery, constituting major driving forces for CA adoption bysmall-scale farmers, despite the constraints such farmers face with weed control.

Overall, the dynamics of CA adaptation and adoption varies from country to country and from region to region within a country; as well as with time, depending on the specific circumstances farmers face. Table 1 offers a list of some of the key factors acting as drivers to CA adoption both at the farm and regional levels. Most of these factors are reversible: drivers can become constraints and vice versa. While not all factors are necessary for CA adoption to take place, Table 1 makes itclear that CA does not have the same probability of being a suitable option in all agro-ecosystems and socioeconomic contexts. Indeed, the development of CA systems and their socio-economic and ecological sustainability are highly site specific. The fine tuning of CA systems requires a continuous adjustment which calls for permanent knowledge generation and sharing among the stakeholders. The success in the shifting process requires: (i)- substantial research efforts on CA systems to generate knowledge needed to develop, adapt, and improve site specific attractive CA technologies and options, and to assess/anticipate their long-term impacts; (ii)- creating favourable conditions allowing a significant involvement of leader farmers and farmers organizations, private companies and extension services in the shifting process and the improvement of their knowledge and management skills; (iii)-a favorable institutional and policy environment allowing all the stakeholders to interact within an effective system.

CHAPTER 3

3 RESEARCH DESIGN AND METHODOLOGY

3.1 Description of the study area

3.1.1 Location

Emba Alaje Woreda is situated between 1422710 and 1439170 north latitude and 530543 and 560142 east longitude, and lies at an altitude of 2,350 metres above sea level (masl). Long-term meteorological data indicate that the mean annual rainfall for the area is 912 millimetres with a mean daily temperature ranging between 9–23 ºC.

Emba Alaje is one of the woredas in the Tigray Region of Ethiopia located 21km from Mekelle. Part of the Debubawi Zone, Emba Alaje is bordered on the south by Endamehoni, on the southwest by the Amhara Region, on the north by Debub Misraqawi Zone, and on the southeast by Raya Azebo. The administrative center of this woreda is AdiShehu.

The study sites Gezeme village is located in three districts of Tigray Region, Northern Ethiopian (See location map). Gezeme Village is found in Emba Alaje at 39029‗18‖E and 12057‗30‖ N with altitude range from 1900 to 2250 MASL and at a distance of 98km south of Mekelle (the capital city of Tigray region) along the high way to Addis Abeba (capital of Ethiopia).

3.1.2 Farming practice

Gezeme village lies in a mixed farming system livelihood zone with both crop and livestock production. Agriculture is rain-fed, relying on the belg rains from mid-January to March, and the kiremti rains mid-June to mid-September. The main crops in the belg season are barley, wheat and peas. The kiremti season is the main crop cultivation season and during this period, barley, wheat, sorghum, teff, peas, lentils and faba beans are cultivated. Wheat and barley are the main food crops which households with surplus sell.

Pulses are the main cash crops in the zone. Traction power is provided by oxen, and weeding activities are done by both men and women. Harvesting is labour intensive and is done by men. Despite the mountainous terrain which limits availability of cultivable land, the combination of fertile soils, adequate rainfall and suitable temperatures produce good yields which make this zone food sufficient. The main hazards facing crop production are rust which affects barley and wheat, bole worms which attack pulses, and crickets which affect wheat, teff and barley.

Treatment is available sometimes free of charge and sometime for cash from the Bureau of Agriculture and Rural Development (BoARD).

The main livestock types are cattle, sheep and goats. Livestock provide draught power, food and income. Ample pasture is available in communal grazing lands, and some households feed cattle with crop residue. Livestock find drinking water in perennial minor rivers, springs and shallow wells- the same sources of water for human consumption. Livestock are a major source of income. Shoats (sheep and goats) are frequently sold during the festival season in April, September, and December.

Cattle herds are allowed to grow as a strategy to mitigate against the effects of potentially severe hardships. In normal years, cattle are sold once their productivity declines. The better-off households replace both oxen and milking cows from within the herd. Poor households have smaller herd sizes, and replace oxen and milking cows by purchasing. Additional income from livestock is earned from the sale of butter, skins, honey and eucalyptus tree sales. Butter and eggs are also important sources of food. Men and children are responsible for herding livestock. The main livestock hazards are pasteurellosis, blackleg, anthrax, foot and mouth disease (FMD), and lump skin diseases (LSD). LSD and blackleg mainly affect cattle.

Petty trading and sale of labour are important livelihood strategies in the livelihood zone. Petty trading is done all year round in open markets and small shops. Agriculture labour opportunities are available locally on the farms of the better-off households, and also in neighbouring Raya valley. Labour opportunities are generally sought after by the very poor and poor households.
The Productive Safety-Net Program (PSNP) was initiated in 1997 Ethiopian Calendar (E.C). It is designed to protect the assets of chronically food insecure households through the provision of food and cash entitlements. Household with able-bodied members get access to their entitlements through public works activities. Households without labour receive support through direct support i.e. without participating in public works.

Seasonal Calendar

There are three seasons in the zone, namely, *Hagay*, January to May (*belg* rains occur during this season), *Keremti* from June to August (mainrainy season), *Kewua* from September to December harvesting period. Agricultural activities are dependanton two seasons: the January to May b*elg* rains, and the June to September *Kiremt*i rains. *Kiremti* is the mainfarming season.

The crop production season begins in January with onset of *belg* rains. During this time, land preparation for barley, wheat and peas begins, getting ready for planting in February. The consumption of *belg* crops begins in April with the pea's harvest, followed by the barley and wheat harvest in June.

Land preparation for the *meher* crops starts in February and continues intermittently until May. Wheat, barley, peas, faba bean and lentils are planted in June with the onset of *kiremti* rains. Consumption begins in September with about half a month of peas - green consumption. The main harvest of peas, and faba bean starts toward the end of September. Barley and wheat are harvested in October and November.

Agriculture labour opportunities are available throughout the year, but particularly during the weeding and harvesting periods in the *kiremti* season. Residents of this zone also migrate to Raya valley from July to August for weeding labour, and from October to November for harvesting labour.

The livestock production season starts in August with cattle births and the start of the wet lactation season. The wet lactation season lasts until January. Butter sales begin with the lactation period. Cattle sales peak in April and May and also in October to December in response to demand for oxen labour. Shoat sales increase during the festival seasons in April (*Fasika*), September (*Meskerem),* and January (*Epiphany*). Honey is collected and sold in May and June and in October and November. Chicken are sold throughout the year.

3.2 Sampling technique and procedure

For this particular study a three-stage sampling procedure was employed. First, three districts having long term meteorological data records which fall in different livelihood zone of the region were selected purposively. At the second sampling stage, the study village in the three districts were again purposively selected. In the third stage, 10% of the total households in each village were sampled randomly for the survey. Hence, data from a total of 119 households, 23 households from Gezeme, 32 households from Etan Zere and 64 households from Merere Villages, was collected for analysis.

3.3 Data collection

The main methodological approach of this research was survey method. Structured and semi-structured interview schedules were used to collect the primary data on the perceptions of the household on climate trends and variability, impact of climate change on the household economy and factors affecting the adaptive capacity of the households in the study sites. Both qualitative and quantitative data was collected with the help of the questionnaires from the sampled households of the three districts. In addition discussions were held with elders and key informants to access additional information on climate change impacts and local adaptation strategies in the study sites. In order to make necessary modification on the questionnaire and to check its appropriateness sample pre-test was conducted and based on it corrections and modification was made to capture the necessary information for the analysis. Secondary data related to the research topic and objective was also collected from respective offices to substantiate the primary data. Furthermore, an inventory of relevant past and current climate change SLM measures was made using the WOCAT. 34

3.4 Method of data analysis

3.4.1 Thematic analysis

Thematic analysis was used to code and summarize the transcripts and notes from the data collections. Thematic analysis is an on-going process of developing and reformulating hypotheses that starts in the field while the data is being recorded and continues until the research is written up (Rubin & Rubin, 2005). In thematic analysis the researcher systematically examines the transcripts for themes and concepts that address the research question and then develops a coding system for labelling all of the text data that relates to each theme or concept (Rubin & Rubin, 2005). The themes and concepts may be based on the literature or may emerge from the data (Rubin & Rubin, 2005). Coded data facilitates the systematic retrieval and analysis of the data into meaningful and manageable “chunks” (Miles & Huberman, 1994).

The interview data were coded into 4 broad categories of themes and 24 specific category using the definitions and rules. These themes were developed before starting to collect data considering the categories of information expected to hear from participants based on previous experience and the literature on CA. This list of categories was then refined and formalized during the data collection based on the information collected. When one third of the information transcribed coding was started by making some adjustments in the definitions and add to gaps in the coding system. At this point the codes and definitions was finalized. The researcher was already familiar with the content of all of the interview data because the data was collected by him and had been reflecting on it throughout the collection process.

Nvivo computer program was used to facilitate the analysis by electronically coding the text and gathering the categorized data into groups for extraction and analysis. Once all the data for a particular code was in one place and read carefully by making marginal notes on paper. The information for each code was summarized into a set of condensed statements that highlight the main points from that data regarding the research question. The summary of statements was revised by systematically re-reading the categorized data and by checking the marginal notes to make sure that the diversity of responses were represented.

3.4.2 Quantitative data analysis

The quantitative data (gathered during the in-depth interviews) were analyzed with regard to land holding size, income source of households, challenges and benefits of current tillage practices, crop residue management, crop rotation and labour situation. Moreover, group discussions and key informants data examined and presented in tabulated forms. The quantitative data are edited, coded and entered in a computer and the Statistical Package SPSS software version 16 is used for the analysis. Multiple response questions are analysed so as to give frequencies and percentages. Tables and graphs are used to present different variables.

Descriptive statistics

Data obtained from the sample households were subjected to statistical analysis. Descriptive statistics are employed to describe, compare and contrast farmers‘ experience on the three main principles of CA. Mean, standard deviation, percentages, average, ratio, chart are also used to analyse the collected data from the sampled households.

CHAPTER 4

4 RESULT AND DISCUSSION

This chapter deals with the analysis and interpretation of the survey data. The survey results on farmers experience on the three principles of conservation agriculture and other associated issues are analysed using descriptive statistics, and opportunities and challenges for the adoption of the technology and the group and key informant discussions will also be presented.

4.1 Characteristic of Sampled Households

The descriptive analysis of the survey indicates that out of 30 sampled households interviewed 30% of the households were women and the average family size was 5.8 with minimum 1 and maximum 11. Moreover, 37% of them have family size less than 5, 60% between 5 and 10and one household with 11in the family (Table 1).

The survey indicates that the level of education of the household heads also varies from completely illiterate up to grade four. According to the survey,57 % of the sampled household heads are illiterate, 17% can read and write without formal education and 17% of the sampled households studied formally up to grade 4. The maximum level of education of the sampled households is grade 4 (Table 1).

The survey analysis on ox ownership reveals that 23% of the sampled households were without any oxen and the majority (37%) had only one ox. Very few the sampled households have (7%) have more than 2 oxen. The majority of the oxen less households were women (86%) (Table 2).
In general, 60% of the women headed households have no ox and 30% of them have one ox. Only 10 of the women headed households have 2 oxen.

Table 1 Characteristics of sampled households

Sex of households	No.	%
Male	21	70
Female	9	30
Education status		
Cannot read and write	17	57
Read and write (traditional)	5	17
Grade 1 – 4	8	27

Grade 5 and above	0	0
Family size		
< 5	11	37
5-10	18	60
>10	1	3

Source: own survey

Table2 Oxen ownership by sample households

Ownership of oxen	No.	%
No Ox	7	23
1 Ox	11	37
2 Oxen	10	33
More than 2 Oxen	2	7
Ownership oxen by women		
No Ox	6	60
1 Ox	3	30
2 Oxen	1	10
More than 2 Oxen	0	0

4.2 Socioeconomic conditions of the sampled households

4.2.1 Land holding and land distribution of the sampled households in the village

The survey data of land holding size of the sample households indicates that the majority of the households own less than 1 ha. According to the survey, 67% of the sampled households own less than 1ha. The remaining 33% of the sampled households own 0.5 – 1ha, but there is no household who owns more than one ha. All sampled households were considered as smallholder farmers according to the description of Adeleke S. (2010), which indicates that a large population size of smallholder farmers usually cultivate less than 1 ha of land (Table 3).

According to the focus group discussion and key informants the size of land per household is decreasing from time to time as some farmers share the land with their own grown up children because of the limited option of economic activity outside the land resource they own.

The descriptive analysis of the land distribution per household indicates that for the majority, the plot of land of the sampled households was not at one location within the village. Only 7% of the households have land at one location, and some own up to 6 pieces of land at different locations. But the majority own 2 and 3 plots of land per household and these are 57% and 23% of the total sampled households, respectively. This shows that the land is so fragmented and difficult to manage.

Table 3 Land holding and land distribution of sampled households

Size of farmland	No.	%
< 0.5	20	67
0.5 – 1	10	33
> 1	0	0
Total	30	100
Land distribution	No	%
1	2	7
2	17	57
3	7	23
4	2	7
5	1	3
6	1	3
Total	30	100

4.2.2 Income source of sampled households

According to the survey, all sampled households depend on crop production for their stay and 80% depend on both crop and livestock. None of the households depend on livestock production only for their stay. Thus, the main economic stay of the sampled households is crop and livestock production (Table 4).

Moreover, in addition to agriculture, 23% of the sampled households have additional income from skilled service work like building and handcrafts. But all of them participate in any public work activities in the village and none of them work as causal labour, sell fire wood as an income and get remittance from relatives (Table 5).

Table 4 Main source of income of sampled households

Main source of income	No.	%

Crop production	30	100
Livestock production	0	0
Both	24	80

Table 5 Additional income source of sampled households

Additional income source	No.	%
Causal	0	0
Skilled	7	23
Fire wood		0
Remittance	0	0
Public work activities	30	100
Trade	1	3

Source: Own survey

4.2.3 Labour situation of the sampled households

All sampled households have less than 5 productive labourers and most sampled households (83%) need to employ additional labour at different stages for the crop production, and only 17% have enough labour for their faming activities. The highest labour requirements are during weeding, harvesting and threshing according to the survey (Table 6).

The result of the survey also shows that most sample households require labour twice, but some of them, about 17%, need up to four times at different stages of crop production. Only one person require five times.

Table 6 Response of sample households on labour situation

Labour availability and requirement	**No**	**%**
No of productive labour		
<3	16	53
3 – 5	14	47
>5	0	0
Employ labour	25	83
Employ labour during		
ploughing	6	20
planting	5	17

weeding	21	70
harvesting	14	47
threshing	12	40
No	6	17
Frequency of labour requirement		
1x	6	20
2x	8	27
3x	4	13
4x	5	17
5x	1	3
0	6	20

Source: Own survey

4.3 Farming practice and CA

In this section the existing farming practice of the farmers is analysed based on the three principles of conservation agriculture. Conservation agriculture (CA) has been proposed as an alternative to conventional tillage to sustainably intensify crop production. Key-elements of CA are minimal soil disturbance (minimum or no-tillage), stubble retention, and the implementation of viable crop rotations.

4.3.1 Tillage

The current tillage practices and perception of the farmers on the effect of tillage on soil erosion, soil water holding capacity and soil fertility revealed that 63% of the sampled households believed that repeated tillage helps to reduce soil erosion and the remaining 37% believe it exposes to soil erosion. If the farmland is sloppy the farmers prefer reduced tillage to reduce soil erosion damage (Table 7).

The survey also shows that 90% of the sampled households believe that repeated tillage improves the water holding capacity of soils and 93% of the sampled households believe that repeated tillage improves fertility of the soil (Table 7).

Table7 Perception of Sampled households on the effect of frequent tillage

Effect of frequent tillage	Response of participants	
	No	%
Reduced Erosion	19	63

Improved water holding capacity	27	90
Improved soil fertility	28	93

Source: Own survey

With regard to ploughing equipment, the survey shows that 100% of the farmers use oxen for ploughing their land and all of them had the same ploughing materials since their life time. Only small changes were made on ploughing techniques to improve the soil water holding capacity following the shortage of rainfall and advice by agricultural officers.According to this survey, 90% of the interviewed households were with more than 10 years of ploughing experience (Table 8).

The advice on the frequency of ploughing by agricultural experts and extension agents was to plough repeatedly (Table 8).

Table 8 Ploughing experience, material use and ploughing technique

Ploughing experience, materials, techniques	Response of participants	
	No	%
Ploughing experience more than 10 years	27	90
Improvement of the ploughing material	30	0
Change in ploughing technique	8	27

4.3.2 Crop residue

The survey on crop residue management by the sample farmers indicates that the majority of the sample householders, that is about 93%, leave crop residue on their farmland where grazing is avoided partly in the watershed. This is a recent experience based on the advice from the GCCA project but in the area where animals are prevented to graze. The size of the stalk left is a minimum of one third of the whole stalk of the crop and varies based on the length of the stalk. Up to now residue is left only if the crop is wheat. No grazing after harvest because the area is prevented from animal grazing on farmland where the study is done. Moreover, the sample households do not leave residue on the farmland in areas where the land is not protected from free grazing (Table 9).

According to the survey all sample households use the residue harvested for fodder purpose only. The majority of the fodder used for their livestock is from crop residue. For 83% of the sample households more than 50% of their feed is crop residue. The remaining 17% sample households exchange it for oxen and labour to feed their livestock (Table 9).

All the sample household farmers understand that crop residue improves fertility and moisture holding capacity of the soil. The interviewed sample households also believe that fallowing improves the fertility of the soil, but according to the survey only 10% them left their land fallow once during the last 5 years. The reason given by the farmers for the low frequency is due to shortage of land.

Table 9 Crop residue management response

	Response of participants	
Crop residue management	No	%
Experience in leaving crop residue atleast 1/3 of the stalk	28	93
Grazing after harvest	0	0
Use of crop residue as fodder	30	100
Use of crop residue for other purpose	0	0
Crop residue improves soil	30	100
Land Fallowing (last 5 years)	3	10
Use of crop residue as fodder		
< 50%	0	0
50 - 75%	4	13
> 75	21	70
Crop residue exchange for oxen	5	17

Source: Own survey

4.3.3 Crop rotation

Based on the survey, all farmers practice crop rotation. But only 83% of them rotate cereals with leguminous crops in four years. But only 53% of the total households rotate crops once in four years. They believe rotating with leguminous crops improves the fertility of the soil and reduce pest attack. They also believe that crop rotation has similar benefit with fallowing. The response of the sample households who don't rotate their crops in four years is because they believe that if the soil is still fertile and/or has waterlogging problem there is no need for rotating. But all the sample households rotate atleast once in four years regardless of the crop choice (Table 10).

Table10 Sample household's response on crop rotation

	Response of respondents

Crop rotation	No	%
Crop rotation practiced	30	100
Frequency of rotations with leguminous crops in the last four years		
No	4	13
once	16	53
Twice	10	33
Improved productivity	30	100

4.4 Challenges for CA adoption

The initial and primary challenge to adoption of CA is the assumption that tillage is essential for agricultural production. Subsequent hindrances to its adoption include, variously, those of intellectual, social, technical, environmental and political characteristics. Key restrictions with mainstreaming CA systems relate to problems with up-scaling which is largely based on the lack of knowledge, lack of expertise, lack of inputs(especially equipment), inadequate financial resources and infrastructure, and poor policy support (AfD, 2009).

The result of the analysis from the group discussion, key informant interview, sampled households response on the challenges can be summarized in the following way:

Lack of adequate knowledge and skills in CA

Conservation agriculture has actually two intellectual barriers to overcome: the first is that CA concept and principles are counterintuitive and contradict the common tillage-based farming experience, which has worked for generations and which often has created cultural values and rural traditions; the second intellectual impediment to adoption is simply the lack of sufficient experiential knowledge about it and the means of acquiring it.

Farmers traditionally believe in working their soils. It is believed that working the soil buries weeds as well as seeds, mineralizes nutrients, breaks soil compaction, aerates the soil and creates a loose bed, suitable for sowing crops. While some of these assertions may be individually true, collectively, they lead to an overall impoverishment of soil quality that is unsuitable in the medium to long term both from an economic and environmental point of view. It is also well accepted that a clean farm is synonymous with hard work and is the opposite of laziness

For actual adoption of CA the farmer would not only need to know about CA elements in general, she/he would need to know the details on how to implement CA elements under the specific conditions of an individual farm. This knowledge is generally not available as a standard technology package off-the-shelf. Worse, CA is a complex and management intensive farming concept in which crop management has to be planned ahead and is mostly proactive and not reactive, as in the standard tillage-based systems.

Problems of soil compaction or uneven surface in tillage-based systems are corrected with tillage, in no-till systems they have to be prevented from occurring from the start. Weed and pest management in conventional tillage systems is often based on chemical or mechanical control as response to the incidence, while in CA the incidence of weeds and other pests is reduced by forward planning of crop rotations.

This increased complexity requires a degree of experience and knowledge, which has to be acquired and learned. For early adopters this learning process and experiential knowledge has therefore involved a lot of trial and error until sufficient local experience and knowledge is accumulated to make the adoption easier. However, the solutions to these practical problems are best developed by the farmers themselves and not by scientists.

At the production level, CA cannot be reduced to a simple standard technology package because of the diversity and variability in agro-ecological and socio-economic conditions of farming. Thus, the interactions between the possible recommended technological components and the location specific conditions of farming must be adequately considered.

The standardised “best bet” production technologies approach tend to be of limited relevance and value for many farmers because CA practices tend to be knowledge intensive; farmers themselves must become involved in fine-tuning the transformation and application of the principles into site- and farm-specific practices.

Lack of knowledge on how to undertake Conservation Agriculture and its benefits

is the most common reason for its slow adoption in Africa. Farmers need to acquire the basic knowledge before attempting to try the practices on their own farms. New technologies that lead to immediate fast adoption often show obvious advantages resulting in fast acceptance and enthusiasm. In many cases this enthusiasm cools down, once the new technology is known and the downsides become visible. With CA it is just the opposite way: it contradicts so much of the knowledge a farmer has learned and been told that the benefits offered by CA are not obvious in the beginning. However, once the step-wise adoption begins, CA improves its performance over time. The more experience producers have with CA, the more convinced and positive is their opinion about it. The less practical experience people have with CA, the more critical and negative is their attitude towards it.

Social Constraints

Farming communities in the developing regions are mostly conservative and risk averse. Any farmer doing something fundamentally different from the others will therefore risk being excluded from the community. Only very strong and individually minded characters would take that step, which leads to social isolation and sometimes even to mocking. Even if those individuals have visible success, the aversion created in the community and the peer pressure can result in other farmers not following.

For adoption of CA, it is therefore not enough to find any progressive farmer who will prove the concept to work, but the farmer must have a socially important role, and be respected and integrated in the community. Ideally the community should be involved from the very beginning to avoid this kind of antagonism.

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 makes it difficult for the uptake of CA practices. 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. Much more important in the process is that the entirecommunity first understands the issues and the changes and benefits involved in adopting CA and jointly looks for solutions.

The survey indicates that the farmers leave crop residues in the farmland protected from grazing only. The group and key informant discussion also shows that under fodder resource scarce conditions without stopping the communal grazing rights leaving crop residue is not possible.

Technical challenges for adaptation

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. Especially, crop rotations, selections of cover crops, issues of integration of crop and livestock have to be discovered and decided upon by the farmers at each location. A diversity of problems arises, very often around weed management, residue management, equipment handling and other technical issues discussed below. This creates the problem that extension agents and advisors in the beginning, when CA is newly introduced in an area cannot give specific advice on practices, but have to develop these practices together with the farmers.

Sufficient availability of crop residues or other mulch

Another important constraint to adoption can be the high opportunity costs for crop residues. 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. The need for crop residues as livestock feed is also a common constraint to CA practice.

A permanent soil cover is an essential aspect of a sustainable CA system but the availability of sufficient biomass both in quantity and throughout the year can create a problem for a variety of reasons.

The need for a permanent soil cover can compete with traditional arrangements such as communal grazing of farmer's fields after harvest. The survey indicates that about 83% of the sample households utilize crop residue for more than 50% of their feed requirements. The remaining 17% sample households exchange it for oxen and labour as a feed for the livestock of the oxen owners.

While farmers value the crop residues as animal feed, among other uses, research by Mesfin et al. (2005) showed that residue retention (3-6 Mg ha-1) can be effective in improving yields due to higher plant available soil water. However, for mulching to be adopted, the long-term benefits from soil and water conservation for crop productivity need to be greater than the potential losses incurred by not using the residues as animal feed.

But CA can lead to yield increases and with this, the quantity of crop residues and so the same amount of residues will still be available for alternative purposes, while the additional quantity can be retained as soil cover (Mrabet, 2002).

The annual seasonal feed demands of the livestock must be integrated into the design and planning of CA rotations so as to ensure adequate supplies. Specific measures that can be adopted include controlled grazing, zero grazing, improved pastures, forage conservation, improvement of the cut-and-carry system, etc. (Mueller et al., 2001).

Shrubs or trees can also be included in the production system, intercropped or planted as fences. Leguminous and forage cover crops can be included in the rotations to improve livestock nutrition, and plant selection must take into account residue production as well as grain production.

Weed control.

Weeds are a major challenge in smallholder cropping systems.One of the main setbacks to Conservation Agriculture is the proliferation of weed species. Eliminating tillage sometimes increases weed pressure in the early years of CA adoption, but weeds decrease over time if controlled well. It is frequently noted that the move from plowing to no-till or minimum till will increase dependence on herbicides in the first years.

With minimum and no-tillage, weed control becomes initially a serious challenge. Generally, Traditional cultivation and hand weeding are cheaper than the use of herbicides. Smallholder farmers do often not have the financial resources and have limited access to credit. Both constrain the adoption of CA practices (Temesgen, 2007).

According to the survey 70% of the households employ labour for weeding. Weeding is the most labour demanding activity according to the survey.

Affordable access to fertilizer and herbicides

In some cases, appropriate use of fertilizers as a complement to legume residues is necessary when initiating CA to increase crop yields and available quantity of crop residues. Nitrogen inputs also help avoid yield penalties with CA, as large carbon inputs to the soil in the form of mulch can promote nitrogen immobilization by microorganisms, making it unavailable for crops.
According to the group discussion and key informant interviews, the price of fertilizer is increasing from time to time that it is becoming difficult to procure for a poor farmer.

Delayed yield benefits.

While CA sometimes increases yields in the long term, farmers may need to wait 3 to 7 years to see yield increases. It takes time for farmers to gain experience with CA, and the improvement of soil structure and fertility is a slow process.

More immediate benefits are likely to be related to savings in labor or other costs. The survey indicates that among the sampled households 83% of them need to employ additional labour to implement their activities. At least 33% of them need at three stages of the crop production.

Availability of CA technologies

Another technical constraint is the simple unavailability of certain technologies or inputs, apart from the financial or other constraints. In many cases where farmers start with CA there are no seeds available for cover crops. Also the availability of equipment, especially no till direct seeding equipment, often is a problem.

By now there are technologies available for most situations, somewhere in the world. However, in a specific location farmers might not be aware of these technologies or they simply have no way to access them. This is where usually external support such as knowledge sharing or eventually even the introduction of specific technologies, such as direct seeding equipment, is required.

During the group discussion and the sampled households also have indicated that no single technology related to CA is introduced by the extension. Although a number of CA implements have been developed at country level. These are modifications to the *maresha* plough that cause minimal soil disturbance. The aim has been to make the CA implements affordable, light and easy to use by smallholder farmers (Rockström et al., 2009; Temesgen, 2007; Temesgen et al., 2009). There is generally little yield benefit from reduced soil disturbance unless the practice is integrated with an adapted soil fertility management including the application of mineral fertilisers and rotations with legumes (Rockström et al., 2009; Burayu et al., 2006).

Financial challenges

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. These constraints exist at all farm size levels, though obviously to different degrees and for different purposes. 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 favourable 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, levelling 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. The larger the farmer, the more important is this hurdle, since a no-till seed drill for example is considerably more expensive than a conventional one. This conflict between the potential improved profit margin on one side and the very concrete and actual investment requirements on the other side often leads to the fact that farmers decide not to change to CA, even though they are convinced about the benefits.

The provision of credit facilities for these cases is one solution, but sometimes also the availability of contractor services or technical advice on how to adapt and modify existing equipment as a low cost intermediate solution to start can help.

Many farmers have restricted access to implements and inputs and are likely to delay planting because they have to sell labour to other fields to earn capital for the purchase of inputs. Although this situation should in essence stimulate adoption of cost saving Conservation Agriculture technologies such as reduced tillage systems and direct seeding many small scale farmers are not finding equipment and herbicides accessible or affordable

.

The lack of subsidies and efficient incentives in a context of high poverty rate in rural areas does not create favourable environment for Conservation Agriculture practices adoption.

Policy issues

Organization of stakeholders in order to improve public commitment is another important factor for the introduction of CA. Use should be made of existing groups such as Farmer Field Schools (FFS) and exchanges between farmers should be promoted through publicity campaigns and study tours. There are many examples of where the development of farmers' groups and movements have stimulated and supported the members to face the change needed to adopt CA.

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 programmes.

4.5 Opportunities for CA adoption

Fortunately, besides the constraints to adoption, there are many opportunities which facilitate the change to CA. The higher the pressure on farmers and the bigger the problems for them to carry on with their business, the easier it is to introduce a change. The result of the analysis from the group discussion, key informant interview, sampled households response on the opportunities for adoption of CA can be summarized as follows:

Crisis and Emergencies

In reality there is a growing awareness about CA in many of these countries in crisis so thatbesides the emergency intervention the respective Ministries of Agriculture can carry onpromoting CA practices. On the other side the frequency of natural disasters seems to increaseand in most countries the emergency rehabilitation projects return year after year followingsimilar events. This allows in practice the support of CA programmes over a longer timeperiod and positive developments have been seen in this way.

The group discussion and key informant information revealed that the rainfall amount and distribution is manifesting from time to time that the farmers have started to use short cycle and early reaching crops.

Increasing Environmental Concerns

Increasing environmental concerns regarding the sustainability of modern farming is putting agriculture under pressure to reform. This is a major opportunity for CA, since it is so far the best available concept for combining high intensive production with long term sustainability of the environment and the resource base.

Rising Input Costs

In most of the cases of Adoption the immediate impact has been that of a reduction in production costs resulting in increased farm income, even if the yield levels would not increase or even decline in the beginning (Hickmann 2006, Lange 2005). The full adoption of CA will result in an overall reduction of the energy inputs in the system (Doets *et al.* 2000) which should be reflected in the energy costs.

Challenges of Climate Change

Climate change is an increasing challenge for agriculture. For conservation agriculture, however, it is also an opportunity, since it can respond to climate change in two ways, harnessing policy support for the further up-scaling of CA.
As a no-tillage cropping system CA holds opportunities for climate change mitigation through carbon sequestration in the soil. By reducing the mineralization of soil organic matter and hence the losses of carbon dioxide from soils through no-tillage, and by adding additional organic matter with soil residues and providing a balanced C-N ratio with crop rotations including legumes, CA contains the essential elements needed for a crop production protocol to qualify for carbon sequestration in agricultural soils.

At the same time CA systems serve for climate change adaptation and as such should be part of national climate change adaptation plans since CA, being resilient to drought stress, reduces the yield variability over time (Tebrügge 2000) thus improving food security. The increased soil organic matter facilitates increased and better water storage in the soil. The mulch cover and the minimum soil disturbance reduces water losses from the soil and the better rooting system of the crops facilitates access to soil water from deeper soil horizons resulting in an overall water saving of about 30 % compared to conventional tillage-based systems (Bot and Benites 2005). This together helps crops to survive drought spells. In addition, run-off losses of excess surface water are avoided through far better infiltration rate sof water into the soil, providing a replenishment of the groundwater aquifers and a more steady flow of rivers and wells even in the dryer months of the year. The increased infiltration capacity of soils under CA also helps to reduce the surface runoff and associated soil erosions well as the flooding created by the water downstream in watersheds. No-tilled soils with anintact vertical macro pore structure and a good mulch cover can withstand even heavy tropical rainstorms of over 100 mm per hour, with a significantly reduced amount of surface runoff (Saturnino and Landers 2002). This can be instrumental for the reduction of flood risks as a climate change adaptation strategy (DBU 2002).

Technical potential for improvement

Conventional tillage-based ways of treating oils has resulted in damage to their inherent productive capacity and their biologically based sustainability as favourable rooting environments. CA is aimed at self-sustaining improvements of the overall health of thesoil/plant ecosystem, and provides a more benign and beneficial alternative.

By avoiding tillage, the loss-rate of CO2 from soil to atmosphere is greatly reduced.

Permanent cover of mulch materials sustains the soil biota, raises the soils' retention/release capacity for water and plant nutrients, and protects the surface from extremes of rainfall and temperature.

Rotations limit pest build-up, favour nutrient cyclingin the soil, and increase levels of soil organic matter at different depths. In the seways CA improves and sustains soil health onland already in good condition, can regenerate land in poor condition, and favours the self-repeating sustainability of soil processes.

Chapter 5

5 Conclusions and recommendations

5.1 Conclusions

This quantitative assessment of farmer's perspectives on the three principles of conservation agriculture assisted to identify the major challenges and opportunities for adoption of the CA. In this study the socio-economic characteristic of the sampled households, the experience and perceptions of minimum tillage, permanent soil cover and crop rotation by sample households was analysed and challenges and opportunities were assessed.

A descriptive statistics was used to analyze the soico-ecomomic characteristics of the sampled household's, current practices and perspectives of the households on minimum tillage, permanent soil cover and crop rotation.

A randomly selected 30 sample households were used for the quantitative survey from Emba Alage Woreda, Gezeme village. The descriptive analysis of the survey on socio-economic characteristics of the sampled household indicates that 30% of the households are women and out of the total households (60%) have 5 to 10 family size with an average family size of 5.8. Majority of the sampled households 57% are illiterate, only 33% of the sampled households can read and write.

The descriptive analysis also shows that all households own less than 1ha of land and fragmented. 80% of the sampled households have pieces of land in 2 to 3 different areas in the village. The majority of the sampled households own 1 ox only and 23 of the sampled households are oxen less. The majority of the sampled women headed households (60%) have no ox. Even out of the oxen less households 80% are women headed households.

The majority of the sampled households (80%) depend for their leaving on crop and livestock production but all households have land and produce crops. Only 23% of them get additional income from off-farm activities like skilled service, hand crafts and trade. But remittance and sale of firewood is not common.

The descriptive analysis of survey also revealed that there is labour shortage during the critical time of crop production. According to the study, 83% of the sampled households employ labour at different critical stages of the crop production but the highest during weeding, harvesting and threshing.

The farming practice of the farmers in relation to the three principles of the CA was assessed in order to look in to the challenges and opportunities for CA adoption. The tillage trend and current experience and its effect on erosion, soil fertility and soil moisture holding capacity, permanent soil cover and use of residue for fodder and other purposes, the experience of crop rotations were assessed quantitatively and made descriptive analysis.

The descriptive analysis of the sampled households revealed that generally repeated tillage reduces soil erosion. This is more effective if the land is on flat land and no intensive rainfall. But they believe the number of tillage reduced on hilly farmlands areas. Majority of the sampled households (63%) believe repeated tillage is not a cause for soil erosion even reduces erosion according to them. But some them believe repeatedly ploughed land becomes fine and can easily be washed away by water and wind. Here it is good to note that 90% of the sampled households have more than 90% ploughing experience.

Similarly, the great majority (90%) of the sampled households believe that repeated tillage improves the soil water holding capacity and soil fertility. They believe refined the soil the more holds water and also avoids weed and facilitates decomposition of organic matter. This advice by the experts and extension agents is to repeatedly plough the land especially for wheat the main crop in the area according to the sample households and even rewarded by the extension system.

The analysis of the survey indicates that all the sampled households have once or twice experience in leaving partly the residue on their field but this is a very recent experience through an advice by a project and after an agreement reached by the community to stop grazing of animals on farmland although generally this is not the experience. The reasons for not leaving residue expressed by the sampled households and group discussion and key in format interview are shortage of livestock feed and free grazing of animals. According to the survey almost all crop residue harvested is used as feed for animals and the survey indicated that three fourth of the livestock feed is from crop residue.

Because the majority of the sampled women headed households have no oxen they exchange the crop residue for ploughing and threshing by oxen owners. Fallowing is also not common these days only few of the sampled households (10%) practiced fallowing. The main reason for not fallowing according to the interviewed sample households is the shortage of land. But all the sampled households believe that fallowing improves soil fertility.

Crop rotation is a common practice in the area as explained during group discussion and key informant discussions. The survey result of the sampled households indicates that all of them practice crop rotation if the soil is relatively poor in soil fertility. The majority (86%) rotated their main crops (cereals) with leguminous crops at least once in the last four years and even 33% of the sampled households rotated twice. The individual survey and discussions indicate that there is strong believe on the benefits of crop rotation for soil fertility, reduced weed infestation and pest attack. They believe it has similar effect with fallowing of land in intervals. I have learnt also that they do not intend to rotate crops on fertile soils and this indicates that the focus of rotation is more on the fertility than the pest incidence or prevalence.

The opportunities and challenges for adoption of CA was also analysed based on the response of the respondents and focus group and key informant discussions. Because of there was no intentional introduction of CA in the village in a complete package involving three principles of CA except the effort to leave permanent cover of crop residue in some farmers it was difficult to directly assess the experience on adoption. It was approached indirectly by assessing the practices of CA in relation to their farming practices and their perception against the scientific believes.

Discussion was done in order to know the status of CA and assess the knowledge of the experts and development agents at Woreda level. The result of the discussion indicates that CA is not officially promoted by the government, until know it is a practice partially test in very spots of the Woreda by projects. Even the knowledge of CA application is very limited and the trend in extension is repeated ploughing of land for main crops as much as possible.

The challenges and opportunities for adoption are similar to other world experience with small holder farmers and similar farming and ecological conditions. The main challenges are lack of knowledge in CA at expertise and farmers level; believe of farmers on tillage, technical, social, financial and policy issues.

Conservation agriculture has actually two intellectual barriers to overcome: the first is that CA concept and principals are counterintuitive and contradict the common tillage-based farming experience, which has worked for generations; the second intellectual impediment to adoption is simply the lack of sufficient experiential knowledge about it at all and the means of acquiring it.

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. Some of the technical challenges are the computing use of crop residue for livestock; weed control in the early years, access to fertilizer and herbicides, delayed yield benefit and availability of CA technologies and their access by small holder farmers. Besides, farmers that are still complacent with their situation are reluctant to change.

In order to start with CA and to successfully create favourable 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, levelling 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 CA equipment which are not affordable by small scale subsistence farmers.

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 programmes.

Likewise, the opportunities for the adoption of CA are similar to the experiences elsewhere in the world with similar farming and agro ecological conditions. The major opportunities sort out from the individual interview, focus group and key informant discussion and literature reviews are crisis during drought, increasing environmental concerns, rising input costs like fertilizer, challenges of climate change and technical potential for improvement.

This study shows that considering the complexities discussed above, it can be concluded that there is no single management practice that can be universally applied in smallholder farms of Ethiopia. Thus, flexible best-bet practices that are tailored to the specific, local conditions are likely to bring about wider adoption. Identifying best-bet practices requires a participatory approach involving farmers from project design through to implementation, and close ties with regional and national extension services.

5.2 Recommendations

Considering the complexity and knowledge-intensive nature of CA systems and the need to tailor CA practices to local conditions, a strong capacity in problem-solving around CA among farmers, development agents and researchers is required. Development and adoption of CA is a dynamic iterative innovation process, involving interacting agronomic, socio-economic and cultural factors that are specific for the local conditions and institutions.

It is important to assist in the formulation and/or mainstreaming and implementation of proper policy for scaling-up Conservation Agriculture practices as part of Sustainable Land Management (SLM) through a program-based approach. Initial advancement with CA Equipment and other inputs Smallholder farmers will be propelled faster towards mainstreaming CA practice through a strategic and more inclusive CA program that includes access to such implements as the jab-planters, animal drawn direct–seeders, cover crop seed and other inputs. Incentives and subsidy systems should be put in place to support initial investments in equipment and inputs particularly for smallscale/poor farmers.

One of the cornerstones to put in place for the promotion and development of Conservation Agriculture is the mainstreaming of this concept in the agricultural, environmental and socio-economical strategies and policies of countries.

This study shows that the challenges and opportunities for adoption of the CA are more or less similar with elsewhere experiences in the world with similar experiences and needs to review the common problems and develop site specific strategies and approaches for promotion of CA.

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Annexes

Annex 1 Household survey questionnaire on use of CA

Full name ____________________ ____________________ ____________________

1. **Land holding size**

   Total _______ Tsemdi, No, of fragmented land ___________

2. **Income source**

   Crop ____ LV_____ both _______

   Causal _____ skilled ______ Sale of fire wood ____ remittance _____

   Food for work _____

   Others ____

3. **Farming practices**

   3.1. Tillage

   How long do you plough using oxen _______________

   Ownership of oxen: One _______ Two _______ More than two ________ Non________

   The positive and negative effect of repeated tillage on erosion, water holding, and fertility of the soil

   Erosion____

   ____

   Water holding capacity____

   ____

   Soil fertility____

   ____

   Do you make any improvements on ploughing equipment you use? Yes ___ No ___

   If yes why? ____

   What type of change do you make? ____

   ____

   Do you make any change in the way of ploughing? Yes ___ No ___

   If yes why? ____

____

What type of change do you make? ______________________________________

____

____

What is the advice given to you by OoARD regarding ploughing?

____

3.2. Permanent Cover

Crop residue management

Do you leave straw? Yes _____ No______

If no how long ___________

Grazed after harvesting? Yes ___ No ___

If yes why ____

If no why ____

Use of harvested residue: Purpose ___________________________________

____

What is the %age contribution of the crop residue for livestock feed? __________%

What is the advantage and disadvantage of leaving crop residue for the soil?

Advantage ____

____

Disadvantage ____

____

Do you leave your land fallow land? Yes ___ No ___

if yes why ____

If no why ____

Do you use mulch ____

3.3. Crop Rotation

Do you rotate crops? Yes ___ No ___ if no why _____________________________

What type of crops____

____

Crop rotation for four rounds starting from now than back on one of rain fed land?

Now _____________ Back ___________ Back _____________ Back __________

What is the advantage and disadvantage of crop rotation?

Advantage ____

____

Disadvantage ____

____

4. **Labour requirement situation**

How many productive labours do you have during main farming activities? ________

Do you employ labour last cropping season? Yes ___ No ___

If yes for what purpose ____

____

Annex 2 Sample household socioeconomic data collection format

S/No	Name of the household head	Sex (male=1 Female =2)	Age	Education	Family size	Land holding size (in Tsmdi)	Main source of HH income