

Review of Adoption and Impact Assessment on Conservation Agriculture in Ethiopia Samerawit

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Abstract

Conservation agriculture plays a great role in improving farming land productivity and mitigating climate change impact. It 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. The paper initially investigates theoretical concepts of conservation agriculture in Ethiopia. It then reviews the adaptation level of conservation agriculture by farm households and its impact on their productivity. The various challenges for the adoption of Conservation agriculture are lack of knowledge in CA at the expertise and farmers' level; the belief of farmers on tillage, technical, social, financial, and policy issues; the market does not supply them with the necessary seeds to carry out intercropping; high input costs, low input availability, and associated high opportunity costs for crop residue; and also lack biomass and residues. Its major impacts are increased labor productivity at the time of soil preparation; it helps with water harvesting strategy; the benefit of crop residue retention is a higher content of organic matter in the soil and higher water infiltration rates, which reduces surface runoff and soil erosion significantly.

Keywords: conservation agriculture, adoption, mitigation, tillage

1. Introduction

1.1 Back Ground of the Review

Agriculture occupies a key position for the Ethiopian economy, which contributes within a single year 85% of employment of the country's population, 95% of land under cultivation and contributes more than 96% total agricultural output. However, the traditional land use system hurts this sector and invites excessive soil erosion by wind and water (runoff) and consequently there is a loss of soil productivity (MOA 2011). Substantial farmers through the country face many risks due to soil erosion, water shortage, erratic rainfall, low crop productivity, food insecurity, substantial forest and surrounding environment depletion. The risks come about because of inappropriate farm practices manifested by frequently growing cereal crops without using crop rotation, long-term tillage, and less planning of cover crops.

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.

Progressing soil erosion causes further difficulties for food production. Ethiopia is known for its historic agriculture, but also for widespread and on-going land degradation. An estimate

based on remote sensing tools indicated that about 26% of the land area in Ethiopia has been degrading over the years 1981-2003, and soil erosion is estimated to reduce food production by at least 2% annually (Ketema and Bauer 2011). The older agricultural areas of the northeast have long been particularly affected, but the highest soil erosion rates are currently being observed in the western parts of the highlands (Stewart and Thiebault 2015).

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. Beside the productivity of some soils is constrained by some other limiting factors even though they have high potential productivity or are naturally fertile.

Another reason for deteriorating soil is tilling. Traditionally, repeated ploughing has been used to loosen the soil and control weeds, and soil tillage has been associated with increased soil fertility. It has, however, recently been recognized that this process leads to a reduction of soil organic matter in the long term, and that most soils therefore degrade under prolonged intensive agriculture. It is not uncommon that farmers in Ethiopia till the land from three to six times during a season. This is especially common when growing teff. Tilling causes a structural degradation of the soils that results in the formation of crusts and compaction, exposing the biological matter to wind and weather and ultimately leading to soil erosion and reduced agricultural productivity. This also causes carbon emissions from the soil, letting the carbon that has been fixating in the soil over time being released in to the atmosphere. Combating soil erosion is therefore central both in order for rural populations to meet their basic needs, and to fight climate change. Due to population increase and limited amount of land, this needs to be done by sustainably increasing the production though efficiency rather than through land expansion.

In many parts of Ethiopia, 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. Moreover, competition for crop residues between livestock feeding and soil mulching is a major cause of the low and slow adoption of CA.

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.

Use of conservation agriculture (CA) could be seen as a potential option for Ethiopia which rely mainly and agriculture seem prime sector that could help in maintaining and improving crop yield, attaining more resilient farming system with reduced risks and hazards, while protecting and stimulating the biological function of the soil. Conservation agriculture has ample benefit like safeguarding the environment, improving agricultural productivity and saving labor and time (MOA 2011).

1.2 Objectives

The general objective of this paper is to review adoption and impact assessment on conservation

agriculture in Ethiopia and the specific objectives are;

1. To review the adoption of conservation agriculture in Ethiopia.
2. To review the impact of conservation agriculture in Ethiopia.

2. Literature Review

2.1. Theoretical Framework

Conservation agriculture: is defined as a sustainable agriculture production system comparing a set of farming practices adapted to the requirements of crops and local conditions of each region, whose farming and soil management techniques protect the soil from erosion and degradation, improve its quality and biodiversity, and contribute to the preservation of the natural resources, water and air, while optimizing yields.

Adoption: According to Doss (2003), adoption can be defined as the continued use of recommended idea or practice by individuals over a reasonably long period of time and the adoption is not a permanent behavior. Adoption is a mental process through which an individual passes from hearing about an innovation to its adoption that follows awareness, interest, evaluation, trial, and adoption stages (Bahadur and Siegfried, 2004).

No-tillage: is a CA agronomic practice for annual crops, and is defined as a way to farm without disturbing the soil through tillage. NT must leave at least 30% of area covered by plant residues right after crop establishment, and crops are sown using machinery which is able to place seeds through plant residues from previous crops. The agronomic practice that best characterizes CA for annual crops in NT, which has the highest degree of soil conservation in annual crops, since the mechanical tillage of the ground is completely suppressed.

Mulching: mulch is a protective covering, usually of organic matter such as leaves, straw or peat that is placed around plants to prevent root freezing, reduce moisture evaporation and suppress weed growth.

Ground covers: is the most widely used CA agronomic practice for perennial crops where by the soil surface between rows of trees remains protected against erosion. With this technique, at least 30% of the soil not covered by the canopy is protected either by sown cover crops, spontaneous vegetation or inert covers, such as pruning residues or tree leaves. For the establishment of sown cover crops and the spread of inert covers, farmers must use methods in coherence with CA principle of minimum soil disturbance.

Minimum mechanical soil disturbance: (i.e. no-tillage) through direct seed and /or fertilizer placement.

Permanent soil organic cover: (at least 30%) with crop residues and /or cover crops.

Species diversification: through varied crop sequences and associations involving at least three different crops.

In Ethiopia, soil conservation practices such as reduced tillage, have throughout history variably been undertaken by farmers in different places as a traditional method. However, the active promotion of CA technology is quite new and started in 1998 by something called the Sasakawa Global 2000 initiative. During the initial period of CA from 1999 to 2003, trials indicated that CA plots on maize, teff and sorghum had higher yields compared to conventional tillage. They also indicated lower production costs.

Despite CA having been introduced in Ethiopia over 16 years ago, adoption of the practice remains low and has not progressed as fast as it could have. Since its introduction, CA has been promoted mainly by NGOs and the private sector with support from agricultural offices at all levels. The Ethiopian government has put in place policies, strategies and manuals that are designed to support CA practices and other forms of sustainable agriculture methods aiming at restoring ecosystems and managing natural resources.

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):

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

One aspect of conservational agriculture is its ability to change the landscape. The destruction of the vegetative cover affects the plants, animals and micro-organisms. Some few profit from the change and turn in to pests. However, most organisms are negatively affected and either they disappear completely or their numbers are drastically reduced. With the conservation of soil cover in conservation agriculture a habitat is created for a number of species that feed on pests, which in turn attracts more insects, birds and other animals. The rotation of crops and cover crops restrains the loss of genetic biodiversity, which is favored with mono-cropping.

Systems, based on high crop residue addition and no tillage, accumulate more carbon in the soil, compared to the loss into the atmosphere resulting from plough-based tillage. During the first years of implementing conservation agriculture the organic matter content of the soil is increased through the decomposition of roots and the contribution of vegetative residues on the surface. This organic material is decomposed slowly, and much of it is incorporated into the soil profile, thus the liberation of carbon to the atmosphere also occurs slowly. In the total balance, carbon is sequestered in the soil, and turns the soil into a net sink of carbon. This could have profound consequences in the fight to reduce greenhouse gas emissions into the atmosphere and thereby help to forestall the calamitous impacts of global warming.

2.2 Empirical Review

Adoption of conservation agriculture in Ethiopia

According to Edries M. (2016) documented that 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.

The main challenges which hinder the adoption of conservation agriculture 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.

CA 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; the second intellectual impediment to adoption is simply the lack of sufficient experiential knowledge about it at all and the means of acquiring it.

According to Mari G. (2016) even if farmers are internally motivated and subjectively convinced by the benefits of CA, and are thereby willing to invest in a conversion to CA, structural challenges need to be overcome in order for large-scale implementation to be feasible. It is of little help that farmers want to do CA if, for example, the market does not supply them with the necessary seeds to carry out intercropping, and even if farmers want to cover their fields with mulch, they are still dependent on local regulations or arrangements that prevent their crop residue from being eaten by the neighbor's livestock.

Among the important barriers were high input costs, low input availability, and possibly low biomass access and associated high opportunity costs for crop residue. The successfulness of the project was in large part due to efficient knowledge-dissemination and relatively high awareness among farmers about the various elements and effects of CA.

One of the biggest barriers towards adoption of CA in developing countries is the lack of biomass and residues. Aresal et al., (2014) found that there was limited potential to grow cover crops during the dry season. In addition to that scarce biomass makes it difficult to get proper mulch, maintaining permanent soil cover can be costly because crops require access to appropriate seeds, which are often not easily available in the market (Mores and McNamara, 2003).

Arslan et al., (2014) found that, in addition to rainfall variability, extension services were the strongest determinants of adoption of CA. The reach of extension services in a village positively affected both adoption and the intensity of adoption (even though it was difficult to identify to which degree extension services included provision of subsidized inputs in their case).

According to Haymanot A.B. (2015) adopter farmers have more age, better educational status, less fertile soil, own greater size of land, minimum distance between the residence and plot, cultivated own land instead of sharecropped and rented, participated in kebele or village administration and takes social responsibility and better accessed extension services in the form of field visit, demonstrations, farm training on sustainable land management specifically SWC and CA practices. On the other hand, non-adopter and partially-adopter farmers were highly negatively affected by those cited variables.

Impacts of conservation agriculture in Ethiopia

According to Mari G.J. (2016), CA involved much less labor, because the need for tilling was removed, and by that freeing uptime for the farmers to complete other tasks. Compared to

conventional agriculture, there might have been some extra labor in sowing because the placing of the seed was more meticulous in row sowing than with the traditional broad sowing, but this was very little compared to the labor spared from land preparation. The data indicated that the relative benefit may be even higher for the poorest farmers who cannot afford to keep their own livestock for ploughing.

Changes in labor demands have shown to give very different results in different areas and with different preconditions. It may be that labor demands decreases in terms of soil preparation, but increases for weeding. Variances in labor depend on e.g. biophysical factors and climate, how and what kinds of CA principles are implemented, and what kinds of weed measures are available and affordable.

Most studies show favorable yield results in cases where crops are drought-stressed. This is because of CA's water retention abilities, where moisture is conserved in the soil, thereby mitigating some of the negative effects of climate change with loss and more erratic rain fall. This implies that CA's strongest benefit is when it's used as a water harvesting strategy (Rockstrom et al., 2009a). The benefit of crop residue retention are higher content of organic matter in the soil and higher water infiltration rates, which reduces surface runoff and soil erosion significantly (Lal 2007). Research has shown that when 35% of the soil surface is covered with uniformly distributed residues, splash erosion will be reduced by up to 85% (FAO 2016).

Wondwossen et al.'s research (2008) from two districts in Ethiopia found that those farmers who had adopted all three components of CA had higher yields than non-adopters, and that yields increased by the number of components adopted. Similarly, adoption of the three components substantially increased labor productivity (yield per unit of labor), implying that most labor is saved from full adoption of all the CA components.

3. Conclusion and Recommendation

Conclusion

Despite Agriculture is the leading sector, in the Ethiopian economy, was and still is characterized by low productivity in general and low yield per unit area in particular. Many people attribute the problem with population explosion, immense environmental degradation, limited accessibility and use of technology, insufficient infrastructure, poor traditional practices and ill thought-out policies. This outdated and tied with bottlenecks, agricultural sector manifested by coupled with population growth at a faster rate, soil fertility depletion and decrease of crop yield, motivate to adopt conservation agriculture (CA) practices, which is agricultural-environmental management system will be taken as a panacea for short-term and long-term policy design.

The success in 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 favorable 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.

Therefore, the adoption of CA, 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.

Recommendation

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.

Further research on win-win approach relative to implementation of CA by smallholder farmers in short-term and long-term over conventional farming, locally flexible and adaptable, changes in yield, selective and appropriate for the type of agro-ecology and soil type, environmentally healthy, and preferred with existing costs of inputs is advisable.

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