Conservation Agriculture in Tanzania

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Chapter 10
Conservation Agriculture in Tanzania

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Abstracts Conservation agriculture is promoted to increase crop production and environmental sustainability. It is proposed to be a solution for the problem of poor agricultural yields and soil degradation in most Sub-Saharan African countries. Conservation agriculture is among the climate-smart practices recommended in Tanzania to curb the impacts caused by climate change. It involve the use of organic soil management practices such as reduced tillage, mulching and leguminous crops. Agroecosystems such as agroforesty, soil organic fertilization and better crop rotation are also included. This chapter reviews the adoption trends of conservation agriculture in Tanzania and their implications to both socio-economic and environmental benefits. We found that the adoption of conservation agricultural practices has spatial and temporal variations. For example in Arusha, farmers use mainly terraces while in Dodoma they use conservational tillage. The '*Matengo pits*' and terraces in the Ruvuma Region have improved both maize and coffee production. In the Southern Agricultural Growth Corridor (SAGCOT) *planting basins* have doubled maize yields compared to that of conventional tillage. In areas with irrigation potentials, conservation agriculture has increased crop yields in drought ecosystems over time. In the northern part of Tanzania the adoption of conservation agriculture has increased the production of food crop crops from an average of 0.5 ton ha^{-1} to 1.5 ton ha^{-1}. Subsequently, maize yields have increased from 12,000 kg to 20,000 kg per 4.8 hectares and 3.75 t per hectare when intercropped with lablab. The interest in adopting conservation agriculture has been driven by its ability to enable some

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yields even in poor rainfall scenario. The review focused on the existing farming management, principles and benefits of conservation agriculture to farmers, society and environment as well as its challenges facing this system.

Keywords Climate change • Semi-arid • Agroforestry • Organic fertilization • Planting basins • Terraces • Environmental services • Food security • Crop yields • Tanzania

10.1 Introduction

Dryland areas cover about 41 % of Earth's surface and sustain the livelihoods of about two billion inhabitants dwelling in these ecosystems albeit under vulnerable ecosystems (Plaza-Bonila et al. 2015; Duru 2015). Drought is exuberated by the global increase in temperature and decrease in rainfall (Ye et al. 2013). Global surface temperature has increased for 0.8 °C during the past century and mostly in the last three decades (Rowhani et al. 2011). The increasing demands of food and impacts of climate change have stressed environmental resources to the extent that its management is more challenging than before (Ahmed et al. 2011).

Soil fertility degradation accrued by poor agronomic practices and artificial chemical fertilization have magnified the problem. However, the expense of chemical fertilization is not afforded by the majority small holders because they are mostly poor. Instead, conservation agriculture is a good preposition to speeds up crop production and environmental conservation (Duru et al. 2015). Conservation agriculture operates in different forms and principles such as terraces or ridges, minimum tillage cropping, cover cropping, large pits and intercropping especially legume intercropping of sweet beans and lablab). Under conservation agriculture, soil microbial communities become responsible for a wide range of soil function and ecological services such as organic matter turnover and nutrient cycling (nitrogen, phosphorus and carbon) to mention few (Lienhard et al. 2013).

The rate of adopting conservation agriculture in Africa (including Tanzania) is insufficient compared to other parts of the world (Fig. 10.1). Basing on the benefits attached to conservation agriculture; we need to emphasize and speed up its adoption and utilization in Africa. Therefore, we need to incorporate conservation agricultural practices i.e. mulching, crop rotation and no tillage to curb food insecurity and poverty.

In Tanzania, conservation agriculture has been in practice for many years ago albeit in some areas it is still in adoption stage (Kimaro et al. 2015). Agronomic practices such as mulching, crop rotation, terraces, no-tillage and agroforestry to mention few are the most applicable soil organic management practices in Tanzania representing conservation agriculture. Maize, millet and sorghum are good example of crops involved in conservation agriculture because their straws are recommendable in organic matter formation (Partey et al. 2011). Figures 10.2, 10.3 and 10.4

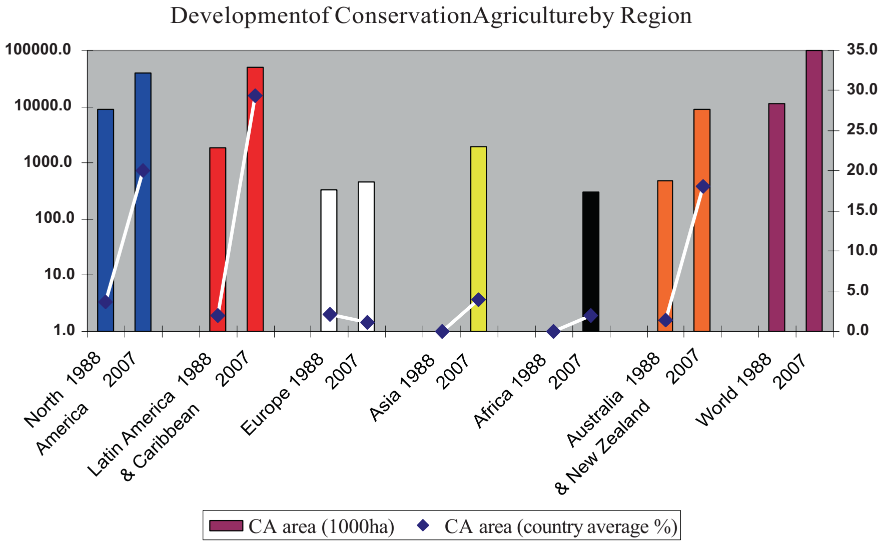

Fig. 10.1 Development of conservation agriculture (CA) over the last 20 years by world region in total area (ha) and as an average percentage across the adopting countries of the respective region. African countries seem to adopt conservation agriculture slowly. It needs more emphasis for a good take off. Afterwards, the continent will increase crop yields in terms of quantity and quality as well as conserving the ecosystems (Source: Adopted from FAO 2008)

Fig. 10.2 Soil cover using crop straws. Straws from maize, rice, millet and sorghum are suitable for soil cover. In this figure, the conservation of moisture is well done. The conservation of soil fertility is also done. This will result to increase in crop yields for the crop produced in the area. This is done to curb the problem of drought and reduced soil fertility which are the major problem for crop production in Tanzania (Source: Adopted from Friedrich et al. 2010)

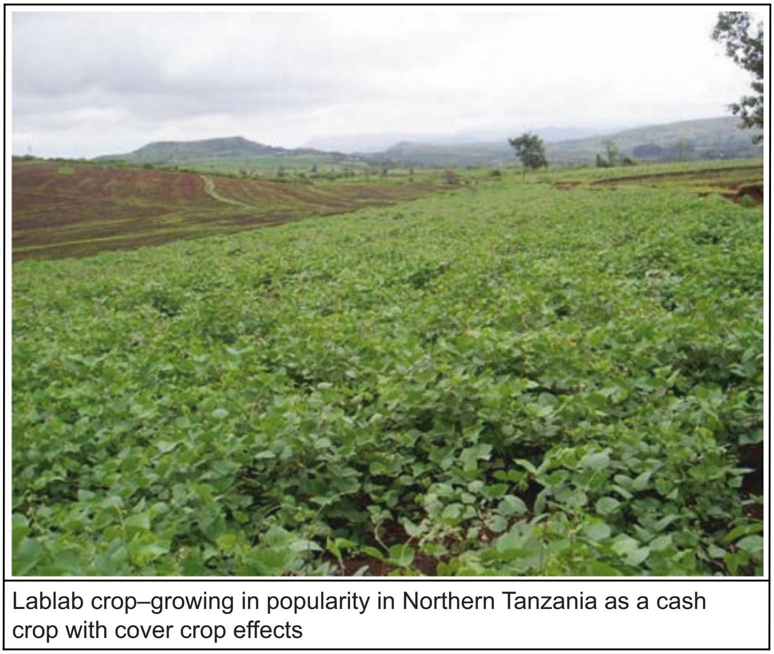

Fig. 10.3 Lablab crop playing duo roles as cash and cover crop. These are hyacinth beans with sufficient shadow to the roots and the roots of other crops when intercropped. In various areas, lablab is intercropped with maize where the yields of both crops are increased in terms of quality and quantity. Therefore, lablab increases crop yield for food and income. Likewise, it conserves the moisture of the soil in the area where grown (Source: Adopted from Friedrich et al. 2010)

portray the overall principles of conservation agriculture in Tanzania ranging from reduced tillage, cover crop to crop rotation.

Subsequently, there are spatial differences in the principles and types of conservation agriculture in different regions of the country. Dodoma, Manyara and Arusha are good examples of the region where conservation agriculture is well adopted and has brought significant contribution to crop yields. Findings show that in Karatu District (Manyara Region) conservation agriculture has improved food security protected ecosystems. In Dodoma Region the use of large pits locally called *chololo* pits have significant contribution to maize, sorghum and millet production (Sosoveli et al. 1999). Therefore, organic amendment of the soil is significant in Africa and Tanzania to overcome the downfall of crop production for 3 % due to soil erosion and land degradation (Partey and Thevathasan 2013). Under conservation agriculture; agronomic and organizational strategies are applied to meet the objectives. Agronomic strategies are; crop-livestock integration in farming systems, increase in biomass inputs to soil systems, incorporation of perennial plants in farming systems, optimization between organic and inorganic nutrient amendments to mention few while the organizational strategies mainly includes these; participatory, farmer-centered research and development as a way to sustain the technique, big assumption

Fig. 10.4 Reduced tillage in northern Tanzania using oxen plough. This reduces the total disturbance of the soil. It leaves the soil more compact with reduced erosion and increase soil organic matter. It also increases the N-mineralization and soil aggregation. The nearby plant leaves are kept between the furrows for further decomposition and formation of organic matter. Therefore, reduced tillage improves and conserves soil fertility (Source: Adopted from FAO 2006)

of responsibilities for agricultural innovation by farmer organizations, including catchment groups, and individual farmers to think and resolve the challenges facing them; capacity building within those organizations and within specialized research and extension agencies. Conservation agriculture operates in a number of aspects as seen in the conceptual framework below (Fig. 10.5). Therefore, there are benefits accrued from conservation agriculture.

10.2 Location and Biophysical Characteristic of the Study Area

10.2.1 Location

Tanzania is located on the eastern coast of Africa, south of the equator between latitudes 1° 00′ S and 11° 48′ S and longitudes 29° 30′ E and 39°45′. Eight countries – Kenya and Uganda in the north, Rwanda, Burundi, Democratic Republic of Congo and Zambia in the west, Malawi and the Republic of Mozambique to the south shore boundaries with Tanzania. The eastern side of Tanzania is a coastline of about 800 km long marking the western side of the Indian Ocean. Tanzania has a total of 945 087 km^2, and out of this area, water body's cover 61, 495 km^2 which is equivalent to 6.52 % of the total area.

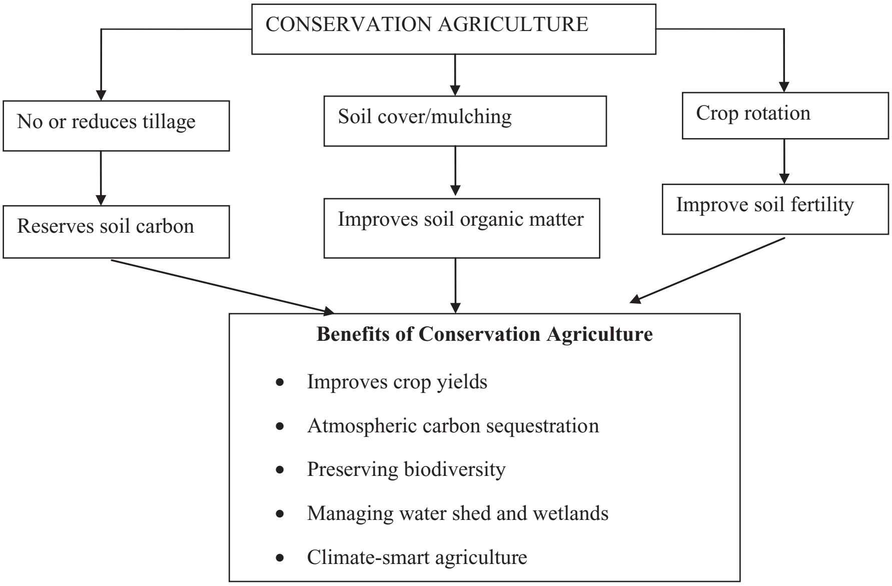

Fig. 10.5 Conceptual framework for conservation agriculture. The framework portrays the major roles of conservation agriculture; first as a tool for increasing crop yields i.e. climate-smart and secondly as a tool for environmental conservation. Conservation agriculture improves the fertility of the soil through no or reduced tillage, mulching and crop rotation. Subsequently, conservation agriculture increases crop yields in terms of quality and quantity. Eventually, it curbs the problem of food insecurity and abject poverty (Source: Created by the authors, 2016)

10.2.2 Climate Impacts

The climate of Tanzania varies according to season and place. Average temperatures range between 17 and 27 °C, depending on location. The hottest period spreads between November and February (25–31 °C) while the coldest period occurs between May and August (15–20 °C). The mean annual rainfall varies considerably from place to place ranging from less than 400 mm to over 2500 mm per annum. Rainfall in about 75 % of the country is erratic and only 21 % of the country can expect an annual rainfall of more than 750 mm with a 90 % probability (Rowhani et al. 2011). According to IPCC (2014a) Tanzania and other sub-Saharan African countries will continue to be vulnerable to the impacts of climate change (CC&I). This is due to their weak adaptive capacities. According to current report by IPCC (2014b), Tanzanian is among thirteen countries worst affected by the impacts of climate change and vulnerability and has weak adaptive capacities. The country is at risk of failing to feed itself because about 70 % of her people depend on rainfed agriculture (Sieber et al. 2015). Rain fed agriculture has extremely failed to ensure food security in the country because rainfall has been low, erratic and unreliable especially the on-set and off-set (Mongi et al. 2010). Vulnerability due to CC&I weaken other social systems of the peoples' livelihoods. Temperature has been fluctuating at the increasing trend whilst rainfall has been more erratic, unreliable and decreasing in most parts of the country (Harvey 2014; Mkonda 2011).

10.2.3 Soil

Soil is the major determinant of agricultural production as it acts as a mother factor for the whole process (URT 2014). Literally, Tanzania has different types and groups of soils which the normal peoples identify them as clay, loam and sand. However, Tanzania adopted the World Reference Base of Soil Resource (WRB) as the system of nomenclature and correlation (URT 2006). According to WRB Tanzania has 19 dominant soil types and they are grouped into two groups namely; ***organic soil and mineral soils*** (Partey et al. 2011; URT 2006). The structure, concepts and definitions of the WRB are strongly influenced by (the philosophy behind and experience gained with) the FAO-UNESCO Soil Classification System.

10.3 Farming Management

Tanzanian agriculture is mainly peasantry in nature. About 75 % of Tanzania agriculture is under small scale farmers (URT 2014). They practice agriculture (Crop production and livestock keeping) in small scale basing on traditional experience (Thierfelder and Wall 2009; URT 2006). Despite of the outreach and extensive services which may be available in some areas of the country; traditional agricultural systems with different fertilization levels are still applied (Albuquerque et al. 2013). The use monocropping, fallowing, shifting cultivation, interpolating and small scale of Agroforestry (Paavola 2008; Agrawala et al. 2003) and monoculture is a dominant farming system all over the country and this system has been the major source of soil infertility. Conservational agriculture is only practiced in few areas as it is perceived by many as a new approach and climate-smart agriculture (Partey and Thevathasan 2013). Therefore, conservation agriculture needs to be effectively utilized to increase crop yields (FAO 2012).

10.4 Conservation Agriculture in Tanzania

Conservational agriculture is the main preposition for agricultural production in Tanzania (Apeldoorn et al. 2011; Rowhani et al. 2011; Agrawala et al. 2003). It involves the use of applicable agronomic practices which perform duo functions of improving crop production and conserving soil fertility (Thierfelder and Wall 2009). No or reduced tillage, crop soil cover and crop rotation are the main principles of using conservation agriculture in Tanzania (Lobell and Burke 2008). Specific practices

Table 10.1 Management practices that can increase soil organic levels of agricultural soils

Management category	Management practices to increase soil carbon
Crop management	Soil fertility enhancement
	Better rotation
	Erosion control
Conservation tillage	Stubble retention
	Reduced tillage
	No tillage
Pasture management	Fertilizer management
	Grazing management
	Earthworm introduction
	Irrigation
	Improved grass species
	Introduction of legumes
	Sown pasture
Organic amendments	Animal manure
	Green manure
	Recycled organics

Source: Modified from Sosoveli et al. (1999)
Above describes the soil management categories and practices employed in conservation agriculture. It covers the principles like no tillage, cover crops and better crop rotation. Organic fertilization of the soil is a good approach towards sustainable agriculture. These practices give more crop yields even in semi-arid areas where retention of soil moister is very low. In areas with irrigation potentials; conservation agriculture can give the best

in conservation agriculture include mulching, mixed farming, crop rotation, terraces, agroforestry to mention few. Table 10.1 shows the management practices which conserve the soil fertility.

Some of the existing conservational agricultural processes are indigenous based (Indigenous Knowledge). To mention few among others includes; Organic farming in Ukara Island (Mwanza region), Rotational grazing in (Arusha region), Matengo Pits or *Ngoro* system in (Ruvuma region). Ngitiri pasture conservation (Shinyanga and Mwanza regions), Terracing and contouring (Arusha, Kilimanjaro, Tanga and Morogoro regions), Mounds and ridges in Rukwa region, Stone barriers on slopes in Korogwe district (Tanga region), Intercropping with trees (Arusha and Kilimanjaro regions), These managements of conservational agriculture have tremendous contribution to the conservation of soil fertility (He et al. 2015; Liaudanskiene et al. 2013). However, these practices are insufficient to curb food insecurity in Tanzania (FAO 2012).

10.5 Principles and Types of Conservation Agriculture in Tanzania

Conservation Agriculture is carried countrywide in different forms and types depending on the topography, soil and available indigenous knowledge (IK). In some regions conservation agriculture practices are sponsored by projects from developmental partners such as US-Agency for International Development (USAID), Department for International Development (DFID), Swedish International Development Agency (SIDA). Principally, conservation agriculture operates on minimal soil disturbance, permanent soil organic matter to cover the soil and then diversified crop rotation (Figs. 10.2, 10.3 and 10.4). According to the review, agroforestry is mainly done in Kilimanjaro, Shinyanga, Arusha and Mbeya regions while crop better crop rotation, inter-cropping, addition of organic manure (straw and animal manure) and mulching are done in several areas in the country (Batjes 2011; Friedrich et al. 2010). These agronomic practices have improved soil fertility and increased crop yields in about all places where they have been applied. In areas with indigenous knowledge, modification has been posed on it to integrate with scientific knowledge and better results have been achieved. CA-SARD project (Conservation Agriculture for Sustainable Agriculture and Rural Development) done in northern part of Tanzania aimed at improving food security and rural livelihoods for small and medium scale farmers through the use of proper conservation agriculture practices (CA SARD Project 2009). The project was participatory in nature as it involved small farmers in conservation agriculture practices aiming to improve their socio-economic livelihoods (FAO 2012). The project achieved good results as more people adopted conservation agriculture and more crops yield were obtained. Thus, conservation agricultural is a good preposition to increase crop yields.

10.6 Adoption of Conservation Agriculture

The rate of adopting conservation agriculture in Tanzania has a temporal and spatial variation. In areas with stressed environment are likely to adopt than those with less environmental stress. Central and northern parts of Tanzania seem to have implemented more conservation agriculture than other parts probably because they are in semi-arid (Branca et al. 2013). A number of projects have been done in those areas to stimulate and instill a sense of conservation agriculture adoption. According to the report by FAO (2006) about 85 % of farmers had adopted conservation agriculture practices to meet the aims of Sustainable Agriculture and Rural Development (SARD). The majority farmers were having about 0.2 hectares under conservation agriculture (Shetto and Owenya 2007). Some farmers adopted reduced tillage in small area (20 × 20 m) while other adopted live cover crops (dolices lablab or mucuna) in slight large area compared to the former. In the southern highlands, *planting basins* has been adopted by farmers facilitated by projects like Southern Agricultural Growth Corridor (SAGCOT). In Arusha about 60 % of the farmers have as well adopted planting basins as conservation agriculture. This helps to retain water around the plant root for long and reduce the magnitude of crop drying and wilting during dry season (Lobell and Burke 2008). Subsequently, about 70 % of farmers have adopted organic fertilization (crop straw and animal manure) in the area. Crop residues are left in the farm after harvest to allow soil decomposition and fertilization (Kimaro et al. 2015). Burning and grazing in the harvested farm is not allowed. This has happened even in some pastoralist societies. Thus, further adoption of conservation agriculture practices should be encouraged.

10.7 Benefits for Farmers

Soil organic management and agronomic practices like mulching, agroforestry, better crop rotation, addition of animal manure and straw have increased crop yields compared to non- application of these organic materials. In various areas where conservation agriculture has been adopted; the production of maize has increased from an average of 0.5 ton ha^{-1} to 1.5 ton ha^{-1} while in other areas the crop yield has increased from 12,000 kg to 20,000 kg per 12 acres and 3.75 ton per hectare when intercropped with lablab (Friedrich et al. 2010; Shetto and Owenya 2007). In a number of regions where conservation agriculture is done there is an increase and stability of crop yields due to improved systems of crop production (Magid et al. 2002). For example, there are increased maize yields in Arusha, Dodoma and Manyara regions as results of adopting conservation agriculture practices especially manure, pits and better crop rotation. Subsequently, conservation agriculture has given higher output to inputs ratios in various areas. The more we nourish the farm the more the yields we get. In Karatu and Babati districts, conservation agriculture has geared the production of maize crop and ensured food security to the majority (Löfstrand 2005). Consequently, the cost of labour has been minimal under conservation agriculture because of reduced farm activities such as reduced or no tillage and therefore the extra workforce have be engaged in other economic activities (diversification). Under conservation agriculture; labour force and time spent is decreased by more than half due to explicitly reduced farm activities (Table 10.2). Therefore, conservation agriculture is a good preposition to curb food insecurity and poverty through increased yields.

In tandem, conservation agriculture has improved resilience of small holders to climate change impacts in various areas especially in semi-arid agro ecological zone by conserving moisture and reducing the severity of the drought (central and north Tanzania). Thus, conservation agriculture practices have improved the livelihoods of most rural population albeit may not have met their desire in full (Ziervogel and Ericksen 2010).

Conservation agriculture has created conducive environment for the society to benefit as a group. It has conserved biodiversity including water sources and make

Table 10.2 Labour and time reduction under conservation agriculture

	Conventional tillage		Conservation agriculture	
Operation/acre	Time	Labour	Time	Labour
Land preparation	8 h	4 persons	3 h	2 persons
Seeding using direct animal planter	7 h	6 persons	2 h	2 persons
Weeding	2 days	4 persons	1 days	2 persons

Source: Modified from Friedrich et al. (2010)
Above shows out the benefits of applying conservation agriculture basing on time spent and number of person involved in labourforce. Undoubtfully, less time and labour is needed under conservation agriculture i.e. no tillage than conventional tillage. This implies that, extra labourforce can be employed for other socio-economic benefits. This can therefore, help to increase the crop yields with fewer resources

it available to people. Plants from agroforestry have protected people from wind blow and ensure their safety. Subsequently, the conserved environment especially contour and terraces control flood and saves the life of people. Then, the society has got better food and water security as a result improved crops yield and environmental services (Shetto and Owenya 2007). Arusha, Kilimanjaro and Southern Highlands regions have got this advantages where adopted.

Conservation agriculture takes place in the environment. And, one of the objectives of adopting it is to conserve the environment and make agricultural production a sustainable industry. It conserves water sources and rivers to serve for both people and ecology. Conservation agriculture has reduced degradation in water sources such as Uluguru Mountain in Morogoro Region, Tanzania which is a source of Ruvu River and supply water to Dar es Salaam city. Over there water is not polluted because there is no chemicals (pesticides and chemical fertilizer) applied for agricultural production farms which would be drained into drainage systems (Kahimba et al. 2014).

Conservation and retention of soil nutrients like carbon, phosphorus, nitrogen and potassium are subject to conservation agriculture (Birch-Thomsen et al. 2007). In turn, soil can retain carbon and reducing its emission to atmosphere. As well it sequesters atmospheric carbon dioxide through plant biomass and fixes it in the soil. Subsequently, mulching tend to protect soil organic matter and permit the growth of microbes in the soil structure. The microbes break down the remains of mulch to produce organic matter and fertilize the soil. Long-term pilling of the decomposed mulch will form a buffer to protect soil erosion from both wind and water. Under conservation agriculture; biodiversity conservation is improved for both above and below ground as it protects sedimentation of rivers and dams due to controlled soil erosion (Stockmann et al. 2013). Ruvu and Rufiji rivers are good examples of this conservation.

Despite the fact that conservation agriculture is a good preposition and increase crops yield and conserve biodiversity; its adoption has been facing some hindrances in Tanzania. Politicians, agricultural officers and related stakeholders tend to advice farmers to undertake tillage using tractors and ploughs with intensive use of industrial inputs especially chemical fertilizers. They aim to increase crop production through maximum utilization of land resources regardless the impacts posed upon. However, the problems and challenges hindering the adoption of conservation agriculture practices by Tanzanian small-holders cut across social, economic and political aspects (Gregersen 2003).

Reports from a number of projects and other research findings reveal the weeding, finance, ploughing mindset, unreliability of crop residuals, soil cover and other community complexities to mention few are some of the barriers toward its adoption. There is an existing mindset that agriculture without tillage is not possible. This notion is propagated by different people from multiple disciplines (McDonagh et al. 2001). Despite of the findings to show that conventional tillage increases soil erosion, loss of nutrients and disturb the formation of organic matter; some agricultural officers ignores these verdict and tell people to undertake conventional tillage(Friedrich et al. 2010). Probably this has some political forces from authorities. However, the emphasis on conventional tillage can be due to food shortage and therefore all means are applied to ensure food availability regardless the environmental and human impacts.

Weed control under reduced or no tillage has been a challenge. This has happened because to control weed without weeding (tillage) it is difficult otherwise the application of weed killers or pesticides can be a solution in controlling weeds. If left, weeds can compete with the plant to undertake soil nutrients and other plant requirements that are why they are not needed in the cropping systems. However, weeds can be decomposed to form organic matter.

Financial problem is another barrier towards the adoption of conservation agriculture and its related practices. This affects widely from the accessibility to information, tools and equipments. Small holders are mainly incapable of accessing conservation agriculture requirements albeit are cheap. Purchasing some conservation agriculture needs and accessing the related goods which demand some money (Birch-Thomsen et al. 2007). All these happen because most of the small-holders are economically weak and therefore they have weak purchasing power.

Weak administration of crop rotation sequence is another barrier toward conservation agriculture in Tanzania. Sometimes farmers face some difficulties in deciding which crop should be in rotation (Partey et al. 2015). Because of their experience and culture they are repeating same crop yearly. For example, in southern highland of Tanzania (Iringa, Njombe, Ruvuma, Rukwa and Mbeya) farmers prefer more maize crop than others. Millet is being adopted slowly and mainly because it is a drought resistant crop and it adapt to the stress of climate change impacts.

Social complexity is another barrier for conservation agriculture practicability. In some areas there are conflict between land users especially between framers and livestock keepers. Farmers may plan to leave crop residues in the farm but pastoralists graze their herds in these farms hence totally affecting the process of creating organic matter. Kilosa and Mvomero districts of Morogoro Region, Tanzania are good examples describing this kind of social complexities. Sometimes the tendency of burning crop residues affects the availability of the organic materials (maize, millet straws) which would be positively used as materials for organic matter formation. And sometimes burning fire especially farms and forest is associated with some local beliefs that as fires burn longer it portrays that the responsible person will live longer. Therefore, societies have different priorities upon conservation agriculture practices and its adoption (Duru 2015).

Albeit there is adoption of conservation agriculture among small-holders, there is a need to speed up the adoption and application by creating awareness among the farmers. If the adoption is not done; we expect to have more soil degradation, increased emission of greenhouse gases and reduced crop yields (FAO 2008). The operating principles in conservation agriculture (no or reduced tillage, soil cover and crop rotation) should be well accommodated altogether using technology or model for simpler implementation and increase crop yield. Subsequently, the emphasis of conservation agriculture adoption and application should consider the country's biophysical characteristics (climate, soil, vegetation to mention few) and socio-economic systems of the people in order to allow and instill the sense of willingness (FAO 2013). In tandem, large scale investment in agricultural industry taking place in Tanzanian land should consider conservation agriculture albeit is in small scale. Economic gain should not be the only motive for large scale investment; the environment should also be conserved (Pelosi et al. 2014).

10.8 Conclusion

According to this reviews; the following conclusions are reached. Conservation agriculture has been in practice in Tanzania land for a long time. Indigenous knowledge was the guiding instrument to undertake conservation agriculture. The *Matengo* pits in Ruvuma, closed pasture (locally *ngitiri*) in Shinyanga region to mention few are some of the conservation agriculture practices done in Tanzania to increase crop yields, control erosion, to mention few. Conservation agriculture practices have contributed to increase crop yields, curb food insecurity and sequester atmospheric carbon dioxide into the soil. Despite of this meager achievement; agricultural officers, politicians and other stakeholders emphasize the use of tractors and oxen plough to till the soil. They believe that agriculture without tillage is utopian. The desire to get more yield had driven some farmers to apply chemical fertilizer and other inputs to speed up crop production, however this chemical application has degraded the natural soil quality and increased the emission of greenhouse gases. The long-term chemical fertilization in various part of the country has degraded of soil. Ismani division in Tanzania is a good example of this severe degradation.

We recommend the adoption of conservation agriculture practices in the farming systems with consideration of spatial differentials in terms of biophysical and socio-economic characteristics of the area. Then, livestock keeping should be integrated with crop production to allow the efficience of the practices. Animal manures and straw from crops (especially maize, rice, millet and sorghum) should be decomposed and used as organic matters in the farms o fertilize the soil. Planners, policy makers, agricultural experts and other agricultural stakeholders should consider conservation agriculture practices in Tanzanian agro-ecosystems for environmental conservation and sustainable agriculture. Subsequently, irrigation potentials should be harnessed in tandem with environmental conservation to enhance ecosystem services (Chai et al. 2015; Duru 2015).

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