Africa Conservation
Tillage Network

CONSERVATION AGRICULTURE IN TANZANIA, A CASE STUDY OF KARATU DISTRICT

An activity of the EU fundedCA2Africa Project

BY

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SUMMARY

Conservation Agriculture (CA) is increasingly promoted in Africa as an alternative for coping with the need to increase food production on the basis of more sustainable farming practices. CA is specifically seen as a way to address the problems of soil degradation resulting from agricultural practices that deplete the organic matter and nutrient content of the soil. It aims at higher crop yields and lower production costs. Yet, success with adopting CA on farms in Africa has been limited (Kassam et al., 2009). This situation therefore prompted the inception of a collaborative project, CA2Africa, which seeks to better understand the reasons for the limited adoption of CA in Africa by analyzing past and on-going CA experiences. A better comprehension of where, when and for whom CA works best, and how CA should be configured in different settings will enable the identification of knowledge gaps for future research, development and promotion of CA in Africa.

The overall objective of this project is to assess and learn jointly from past and on-going CA experiences under which conditions and to what extent does CA strengthen the socio-economic position of landholders in Africa. For this purpose, a consortium comprising 10 highly experienced, complementary European, African and International partners has been assembled. It will develop an up-to date knowledge database on CA practices in Africa. Biophysical, socioeconomic and conceptual models of innovation systems will be applied to a series of case studies across five regions in Africa to analyze the impact and adoption of CA at different scales (field, farm, and region). This will facilitate the identification of pathways to make models readily applicable for decision-makers in different African regions and under different conditions. It will allow set the agenda for future research, development and promotion of CA in Africa.

The project brings together the major research players involved with CA in Africa to share, assess and learn together with practitioners from past and ongoing experiences on CA in five regions across Africa. The Eastern Africa platform has two case studies which include; Bungoma district in Kenya and Karatu district in Tanzania. Therefore this report presents a brief profile description of Karatu district case study.

1.0 Contextual information of project/site

1.1 Biophysical conditions

1.1.1 Location

Karatu is one of five districts in Arusha Region, located in the northern part of Tanzania (figure 1.0). It became an administrative district in 1997. It is located south of the equator between latitudes 3°10'–4°00'S and longitude 34°47'E and borders Mbulu District to the west, Ngorongoro District to the north, Babati District to the south-east, and Monduli District to the east. The district occupies an area of 3300 km^2 classified under land use as follows: arable land 102,573 ha; pastureland 155,808 ha; forest, bush and tree cover 61,218 ha; and Lake Eyasi 1060 ha.

The district has 4 administrative divisions, 13 wards and 45 registered villages with its administrative headquarters in Karatu town approximately 150 km west of Arusha town. It is an important stopover for most tourists heading for Ngorongoro and Serengeti National Parks.

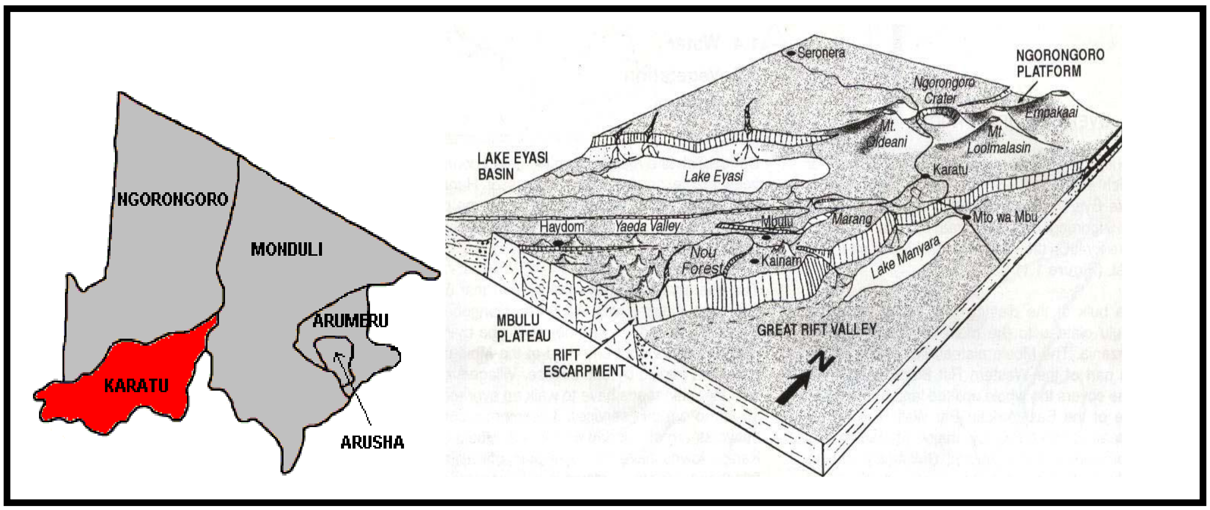

Figure 1.0 Map of Karatu district in Arusha region and its land physiography, (Richard *et.al*, 2007).

Lakes Manyara and Eyasi in the district influence the climate through low and high pressure belt mechanisms, especially at the end of the dry season when winds blow vigorously drying up the landscape and vegetation as well as moving the clouds away from localized areas. Based on relief, land physiography and drainage pattern, Karatu can be categorized into three zones—uplands, midlands and lowlands—with altitude ranging from 1000 to 1900 m. There is a clearly defined escarpment in the Rift Valley, rising to more than 400 m. Lake Manyara and Manyara National Park occupy the plains at the bottom of the Rift. At the top of the Manyara Escarpment in the highlands around Karatu, vegetation becomes more lush and green. The extinct, gently sloping Ol Deani volcano is a prominent feature of the landscape. In the past, the area around Karatu and Ol Deani was of great importance to the German colonial administration. The area's cool climate, fertile green hills, and pleasing views were popular with settlers and farmers. Extensive arable fields cover the slopes of the volcano and the land around Karatu town. Coffee was the main export crop, and a few large farms that remain in private ownership still cultivate the cash crop on the hills and valleys outside the town, (Richard *et. al*., 2007).

1.1.2 Climate

- **Rainfall**

Rainfall in the district is bimodal; the short rains fall between October and December and the long rains ('masika') between March and June (KDC 2001). Rainfall may range from less than 400 mm in the Eyasi Basin to over 1000 mm in the highlands with rain zones classified as semi-arid (300–700 mm/year) and sub-humid (700–1200 mm/year) respectively. The wettest month is April. Rainfall varies considerably between years, especially in the semi-arid region, where the coefficient of variation of annual rainfall is 30–40% (Meindertsman *et al.,* 1997). Duration and intensity of individual storms are unpredictable. Rainfall intensity can be very high, causing erosion, particularly at the onset of the rainy season when soils are bare.

- **Humidity and evapotraspiration**

Relative air humidity increases during the rainy months from about 55% in October to about 75% in April/May, (Meindertsman *et al.,* 1997). Potential evapotranspiration measured at Karatu is about 1440 mm per year (average 120 mm per month) and generally increases during the dry season, reaching a maximum in November just before the rains start.

- **Temperature**

Temperature decreases with increasing elevation by about 0.6°C for every 100 m. Mean annual temperature ranges from 15°C in November (forest) to 24°C at the level of Lake Eyasi. The coldest months are June–August, the warmest October–April.

1.1.3 Soils

Soils vary depending on their origin and location. Shallow soils with low fertility are found on summits and slopes. Clay soils of moderate fertility are found in the valleys in gently rounded summits and on slopes overlying soft gneiss rocks. Of volcanic origin are the predominantly clay soils, some very shallow but very fertile. Found in the Ngorongoro land system they include moderately steep foothill ridges of volcanic cones, lava plains and foothill slopes. Soils with recent ash deposits are rich in salts and are highly erodible Soils on the long, gentle slopes at the lower ends of foothills, scarp slopes and the flat plains of Lake Eyasi are mainly sand and clay, derived from basement gneiss and granite, but around Ol Deani volcano clays are derived from basalt by the action of wind, water and gravity. Fertility is low to moderate. This land system also includes most *mbuga* soils, in which evaporation causes sodium and calcium salts to accumulate

1.2 Socio-economic conditions

- **Human population and demography**

The district is a traditional home to the Iraqw tribe. Other minor tribes are the Bardaigs, who are pastoralists, and the Hadzabe, noted mainly as hunters and gatherers. The official population of the district is 178,434 people: 92,895 men and 85,539 women, growing at an annual rate of 3.2% and aggregated into 33,000 households. The average population density is 52 persons/km^2 with low densities in the western zone along Lake Eyasi (7–10 persons/km^2) and higher densities (100 persons/km$^{2)}$ in Karatu and Mbulumbulu division, (URT 2004b). Most people live in the higher rainfall areas where the average population density tends to be high.

- **Economic activities and marketing**

Arable farming and pastoralism are the two main kinds of land use. Crop and livestock production are by far the most important economic sectors, employing over 90% of the labour force in the district. Farming is largely rain-fed. Variation in soil, topography and climate determine land-use potential.

Apart from agriculture, tourism and associated businesses such as shops, hotels and restaurants are another significant source of income for the people of Karatu. Besides, other local economic activities include producing beer, bee- keeping and selling forest products such as charcoal. Farms provide a significant source of income, especially during planting and harvesting, when many people are employed as casual labourers.

- **Crop production and mechanization:**

About 102,578 ha of the district's land area is classified as suitable for cultivation. The principal crops grown in Karatu include maize, beans and paddy (rice). Mbulumbulu and Karatu Divisions in the highlands produce wheat, barley, beans, maize, coffee, flowers, pigeon pea and safflower. Endabash Division in the midlands produces maize, beans, pigeon pea, sorghum, finger millet and sunflower.

Previously, with adequate and well-distributed rainfall (> 800 mm), agriculture in the highlands was very productive but in recent years crop yields have declined, mainly due to unreliable rainfall (erratic precipitation and lower annual totals) and poor soil fertility (KDC 2001). Households have responded by diversifying into producing *Dolichos lablab*, finger millet, sorghum and short-term maize varieties, which are more droughts tolerant. Maize and beans are primarily grown as staple subsistence food crops but in some high-potential areas in the highlands, they are both cash and subsistence food crops.

Improvements to crop production have focused on introducing improved varieties, replenishing soil fertility with inorganic fertilizers, controlling erosion, planting well timed and with proper spacing, and weeding. Maize intercropped with pigeon pea is the most common crop-production system in the highlands and midlands. In the lowlands agriculture is unsuitable unless irrigated. The most limiting factor in the lowlands is low rainfall, an average of 300 mm (Meindertsman et al., 1997).

The district has a good number of farm implements: 1700 tractors, 21 combine harvesters, 3900 ox ploughs, and a good number of draught animals (URT 2004b), but their utility to some extent tends to follows the agroecological zones, for instance, in the highlands where wheat and barley are mostly cultivated tractors are used for ploughing, harrowing, applying herbicides, harvesting and transportation. Animal draught power is used for ploughing with a mouldboard plough. Oxen are normally used as a source of animal power, mainly for ploughing and transportation, while donkeys are normally used for transportation. Seeding is often done by hand behind the plough.

- **Livestock production:**

Animals kept in the district are mainly indigenous cattle (149,242), dairy cattle (2892), goats (239,052), dairy goats (100), sheep (43,961), indigenous chickens (62,062), pigs (8836) and donkeys. An average of 7.5% of the population engages only in livestock keeping, especially the Barbaigs being the pastoralist community (URT 2004b). About 90% of the households engage in mixed farming. Crop–livestock integration helps farmers minimize risk and recycle nutrients. Crop residue is used as animal feed and in turn farmyard manure is applied on the field to improve soil fertility. Donkeys and oxen are used for cultivation and transportation. Heifer Project Tanzania has been promoting zero grazing and improved dairy cattle and goats in the area. Due to land scarcity, it is increasingly difficult for pastoralists to find adequate open grazing land for their livestock. Village governments try to balance the need for land between crop farmers and pastoralists and to minimize conflict by allocating areas where pastoralists can graze their livestock.

- **Communication in the area**:

The only tarmac road in the study area connects Makuyuni and Ngorongoro Conservation Area. The district has gravel roads totaling 514 km, district roads 210 km, regional roads 108 km, and a trunk road 52 km. This implies that it is easily accessible during dry weather but generally poorly to very poorly accessible during rainy seasons, when, and often with great difficulty, only four-wheel-drive vehicles can pass with passability estimated at 62% (URT 2004b). Main road outlets are Makuyuni–Ngorongoro that proceeds to Serengeti up to Shinyanga and Mwanza. In Karatu there is a road connection to Mbulu and Babati Districts.

Karatu town has good telephone services, provided by a number of mobile phones— Vodacom, airtel and Buzz. At Karatu town, Internet services are available. Personal communication with farmers has shown that accessibility to mobile phones has helped them to get reliable information about inputs and availability of markets (prices and type of community required). The district's four airstrips are used mainly by tourists and large-scale farmers

1.3 Institutional environment

Agricultural production situation in Karatu district have attracted several institution and/or organizations both local and international, all with prime objective of improving farming conditions and ensuring sustainable agriculture that brings about food security in the area through various intervention such as right inputs provision, capacity building, on-farm demonstrations of new technologies, remedial or mitigation measures of degrade soils advocacy among other functions. Some of these organizations and their functions are briefly highlighted in table 1.0 below:

Institution/ Organization	**Activities/ achievements**
Karatu District Office a. District Agriculture and Livestock Development Office (DALDO)	• put in place measures to conserve soil and water in selected areas of the Karatu highlands • Coordinated numerous activities such as tree planting programs and agro-forestry in the district. • Under the Conservation Tillage Project (CTP), NALEP program, , it promoted of a technical package for obligatory construction of contours, draught-animal power ripping, use of farmyard manure, specific row spacing, use of chemical fertilizer and weeding • In 1996, SARI with the support of GTZ started Sub-soiling services under reduced tillage.
b. Regional integrated Development Programme (RIDEP) –(1980-1984)	• A national agricultural project aimed at improving agricultural productivity through soil and water conservation. Project activities included constructing contours, managing natural resources through tree planting, and constructing and maintaining roads. Many trees were planted and bunds constructed.
Karatu Development Association (KDA)	• KDA, registered in 1991 with the aim of alleviating poverty, the organization was sponsored by the Danish Association for

	International Cooperation (MS-Tanzania) to engage in microfinance, develop agriculture, and improve the environment through extension and demonstration activities, and to provide or make information accessible. • The association started demonstration plots on a variety crops—sorghum, paddy and pasture. Many tree seedlings were grown for sale and for free distribution. Demonstrations of how to use the green manure of mucuna and lablab were set in village communal farms and at church and school sites. Farmers appreciated the improvements in soil fertility brought about by the leguminous cover crops.
Selian Agriculture Research Institute (SARI)	• Agricultural research institutes in Tanzania. • Key promoter of conservation agriculture in the Northern Zone of Tanzania including Karatu District. • SARI officers have been pioneering and spearheading experiments and field testing use of indigenous cover crops such as *Dolichos lablab*, pigeon pea and *mucuna*. • SARI is also the main supplier of cover crop seeds in Tanzania and it coordinates sub-soiling services in collaboration with TFSC (with support from GTZ).
Tanzania Farmers Service Centre (TFSC)	• TFSC and GTZ have been promoting conservation agriculture and its intervention has improved agriculture in Karatu District. • They offer farmers sub-soiling services with a tractor. • In collaboration with SARI, it has had demonstration plot with cover crops and minimum and no-tillage trials; • It holds workshops and courses on sustainable agriculture, the use of agricultural machinery and efficient crop production; • It sells agricultural machinery and spare parts; and it services agricultural machinery.
Tanganyika Farmers Association (TFA)	• Supplies agricultural inputs such as seed, fertilizer, pesticides and fungicides, hand tools, draught-animal power equipment and

	sprayers with branches throughout country including in Karatu District. • It displays agricultural implements and promotes improved and new varieties of crops e.g it has distributed lablab seeds to create awareness.
Conservation Agriculture for Sustainable agriculture and Rural Development project (CA-SARD)	• This is FAO-supported and German-funded project in Karatu district. Karatu was chosen because the donor intended to build on ongoing pilot activities in conservation agriculture. • The pilot activities of SARI in collaboration with GTZ/TFSC, ACT, SFI, FAO, IFAD and others convinced the donor to introduce this project with the objective of scaling up conservation agriculture activities. SARI is hosting the project office. • The project uses farmer field school (FFS) concept to introduce and implement conservation agriculture. This has proved useful for discussing and assessing various conservation agriculture features at the common FFS field and in the farmers' fields simultaneously facilitating the adoption and diffusion of the technology.

(Source: Richard *et al*., 2007)

2.0 History/trajectory of work related to CA in the project/site

In the latter part of the 1990s, sub-soiling (ripping) was introduced in Karatu district (Bishop-Sambrook *et al*., 2004). Key facilitators of conservation agriculture in Karatu include KDA, SARI and TFSC. In 1997, a soil conservation project began in Qurus village. The aim of the project was to encourage the adoption of cover crops such as *mucuna*, *lablab* and sunn hemp (*Crotalaria spp.)* through village demonstrations coordinated by KDA. In 1998/99 *mucuna* performed well during the first year of the project, but it was not adopted. It lacked marketing opportunities as it was a new product without established marketing channels. Furthermore, prolonged drought led to poor germination of seeds and poor establishment of cover crops (Richard *et al*. 2007)

In 1998/2000, SARI and TFSC conducted joint sub-soiling activities and cover crop improvement by introducing lablab, which fetches a ready market and is edible. Development of conservation agriculture under SARI and TFSC was in three phases. Phase 1 included sub-soiling with tractor (1998) and involved 28 free demonstration plots sponsored by GTZ and implemented by TFSC. The demonstration aimed at motivating farmers to adopt heavy tillage using the chisel plough in the first year, essentially to break up the hardpan and de-compact the soil.

Phase 2, introduced cover crops in 1999/2000 in 14 trial sites of sub-soiled plots while Phase 3, used no-till and direct planting equipment such as jab planters, draught animal power knife- rollers, no-till planters and sprayers, and tractor-mounted direct-seed drills introduced in 2002.

It was realized that to some extent pigeon pea, which is commonly intercropped with maize, could be used as a cover crop. For many years, farmers had observed the positive impact of pigeon pea on soil fertility, the crop's ability to break hardpan, and its positive impact on moisture retention and weed control, particularly of noxious weeds such as *Digitaria spp.* (Richard *et.al*, 2007).

3.0 Recommended CA practices/technologies

Conservation agriculture is a technique that is adapted to conserve, improve and make more efficient use of natural resources through integrated management of available soil, water and biological resources combined with external inputs. It contributes to environmental conservation as well as to enhance and sustainable agricultural production. It can also be referred to as resource-efficient and resource- effective agriculture.

It is anchored on simultaneous practice of the following principles:

- ✓ Reduce or minimize soil disturbance (that is, soil disturbance in crop production is restricted to the absolute minimum).
- ✓ Maintain soil cover of live or dead vegetal matter on the soil surface. This implies that crop residue should not be burned or removed from the fields.
- ✓ Rotate crops over several seasons. In addition to minimizing the build-up of diseases or pests, crop rotation is essential in sustainable farming as it allows differential use of the soil over time, thereby optimizing plant nutrient use through synergy between different crop types. Alternating shallow-rooting crops with deep-rooting ones is also an important feature in deciding crops in a rotation.

- **Soil cover**

The source of soil cover for conventional farming has been crop residue that after having been chopped for animal fodder is returned to the fields. Managing permanent soil cover is still a problem in annual crop fields but in coffee plantations it has been possible in this region. Generally, a large amount of the soil cover is removed for uses such as livestock feeding, fuel and fencing or is simply burned to get rid of it. After being introduced to conservation agriculture, farmers are striving to ensure soil cover. It is a matter of too little biomass, inadequate knowledge of how to establish pasture plots, and persistent conflicts of interest.

In 2000 mucuna and lablab were introduced as cover crops in the case study area. Many farmers prefer lablab because besides being useful in improving soil fertility, the seeds can serve as food and as a cash crop; the leaves can be used as green vegetables, especially during the dry season when it is not easy to get other green vegetables. At least 350 farmers under an FFS group scheme have at least a plot of cover crop, either mucuna or lablab, where more than 60% of the maize fields are intercropped with pigeon peas (Richard *et.al*, 2007)

After harvesting maize, pigeon pea is left in the field to be harvested later; therefore, it covers the area during the dry season and forms a very good canopy.

Cover crops are managed mechanically by chopping them with slashers; a few people use knife-rollers. Many farmers are hesitant to use chemicals because of the lack of technical know-how and low purchasing power.

In some way soil cover is traditionally practiced in the study area but proper management to fit it into the conservation agriculture system is lacking. Farmers interviewed declared that soil under pumpkin cover looks better in terms of soil moisture conservation and weed control than in areas devoid of such cover. Limited knowledge of how to manage soil cover, inadequate rainfall, fast-decomposing leguminous biomass (lablab, mucuna and pigeon pea), free-range grazing, cut-and-carry methods of handling crop leftovers, and lack of enough planting materials (seeds) have limited attainment of permanent soil cover.

Generally, crop residue is meant for dry feeding for animals or is left in the field for free grazing after harvesting. Managing soil cover is still a big problem under conservation agriculture systems.

Crop rotation under conservation agriculture: Crop rotation under conservation agriculture generally is Dolichos lablab or pigeon pea followed by maize and then wheat. Farmers also rotate crops in intercropped fields of maize and pigeon pea or beans with a pure stand of barley or wheat. Farmers are relatively aware of the benefits they get from crop rotation such as improved soil fertility and control of weeds, pests and diseases. However, in areas with relatively high population density (farm size < 2 acres), farmers want to maximize yields and have different crops on the same piece of land; hence intercropping remains the main option. Households have land enough only to grow their staple food (maize), and cannot reduce the area under maize let alone not grow it for any season. Therefore, Intercropping is mostly desired as it allows the farmers to spread the risks (within the same small field) so that if one crop fails the other may produce something (Richard *et.al*, 2007).

- **Minimum soil disturbance/ reduced tillage**

This has been achieved in the region through the use of conservation equipment or implements which include manual hand hoes, slasher or panga, animal-drawn implements such as knife-roller, draught-animal power direct planter and ripper with option of planter attachment. The hand jab planter is meant for planting through crop residues and crop cover with no tillage. TFSC has used sub-soilers on several farms (28 farmers) but due to the high cost of hiring the equipment (TZS 60,000 or USD 60 per acre) diffusion was slow and in some places it never took place.

Through the CASARD project a number of conservation agriculture implements (knife rollers, no-till planters, jab planters, rippers) were imported from Brazil in 2004 and have been used by farmers in the FFS groups. These conservation agriculture implements have different options to suit different categories of farmers.

The jab planter was for hand-hoe users while direct seed planters were for draught animal users. Institutions promoting these conservation agriculture technologies had intensive demonstration sessions and supplied leaflets as operational manuals.

The jab planter is popular because it is cheap, easy to operate and available locally. The direct seed planter is more complicated to use because of the need to calibrate the seed rate and manage the harnessing. For farmers with small plots the jab planter is the right tool. Nandra is the main supplier of rippers, jab planters, chisel ploughs and ripper planters. Inability to purchase or hire conservation agriculture implements is one of the significant constraints to adopting conservation agriculture. It affects all types of farmers although in different ways. Some of the implements are not readily available in Karatu District or even in nearby regions

4.0 Impact of CA

Land degradation has played a crucial role in the study district in sparking the interest in the elements of conservation agriculture. However, it takes the impact of HIV/AIDS and severe labour shortages which act as the catalyst for change, propelling African smallholders down the path of reduced tillage and cover crops, towards conservation agriculture (Bishop-Sombrook *et al*. 2004). A major cause of this land degradation is continuous intensive soil preparation by hoe or plough, which together with the removal or burning of crop residues leaves the soil exposed to climatic hazards such as rain, wind and sun. Conventional tillage using ox-or tractor drawn ploughs as practiced in the area has over the years been perceived as the indicator of farm systems modernization in developing countries while in the real sense have caused serious adverse effects on the long term productivity of erosion-prone tropical soils in the area (Richard *et.al*, 2007).

The introduction of Conservation Agriculture (CA) Karatu district has offered a window of opportunity to reverse these degraded soils into productive soils and thereby improves crop yields and reduces land degradation

4.1 Agronomic and environmental aspects at the field level

Different projects and authors have reported an increase in yields after using conservation agriculture practices in various part of the world and farmers in karatu districts have witnessed the same. They have realized increase in yields especially in the second year after applying at least one of the practices recommended by the Conservation agriculture principles. They further explained that leaving crop residue has reduced runoff and soil erosion and improved the soil condition. They also indicated that the soil had changed in colour from red to dark red after three years of using crop residue which is an indication of reversed or improved soil conditions. Besides, under soil cover the number of weedings required has reduced tremendously.

Most farmers depend on family labour but hire additional labour during labour peaks, like weeding. Therefore, reducing labour is crucial to farmers. Labour to prepare land, slash, collect trash, burn and till can be reduced to slashing only. Conservation agriculture definitely affects labour. With the introduction of direct seed planters, fewer people are needed to plant this cut the cost of labour and reduced the frustration associated with labour peak. At most, two people are required to rip, plant and cover the seed on two acres in one day. Direct seeding reduces drudgery and frees up time for people to rest and attend to other chores. Under conservation agriculture farmers have changed the timing of their farm operations; since land preparation is reduced planting is timely at onset of rain which leads good germination of seeds.

4.2 Socio-economic aspects at the farm level

By adopting conservation agriculture practices, the workload and the division of labour between men and women have changed. Farmers who have adopted zero tillage simply wait for planting time as they do not plough. Men, traditionally responsible for land preparation, are no longer occupied by that task, so they have more time to do other development activities. Women and children were responsible for planting. This has changed too. Now men also are involved in operating the no-till direct seeders, which takes less time, hence women have more opportunity to do other activities. In many areas, weeding is still done by scratching or uprooting, as the soil cover is not sufficient to suppress weeds.

Employment for small-scale farmers has been well distributed throughout the year; that is, even in dry seasons they can be harvesting cover crops (lablab, pigeon pea, mucuna) used to suppress weeds. Labour requirements for peak periods have been reduced or the work distributed to slack periods. For example, the critical need for time and labour in the peak period of land preparation and weeding has been minimized while slack time during dry seasons is used for harvesting cover crop seeds. Comparing time and costs required for weeding in conventional fields with direct planting through cover crops on a small scale in area showed many savings in using conservation agriculture components.

The aspect of forming local groups such as Farmers Fields Schools, have form a consortiums that increase farmers bargaining power through training, marketing produce and accessing credit from local microfinance institutions and willing funding from sponsoring organizations besides establishing strong cohesiveness and integration in the society which foster unity and coexistence and sharing of experiences. The graduates from these schools may get involved in offering training to other farmers for a fee, thus providing a form of employment.

4.3 Institutional aspect

The introduction and adoption of conservation agriculture in the district have created an enabling environment for various organizations both local and international to have a lot of investment, project development and implementation in new farming practices. This is has been achieved in the district because of established groupings such as Farmers field schools. Organizations have enabled to advanced capacity building programs through farmers training and workshops and developed farmers field school's curriculum. Information sharing and networking in enforcing sustainable agriculture innovations is sufficient in the district among the partners or collaborators. Supply of inputs and conservation agriculture equipment is also a major achievement that institutions in the region have been engaged in and prudently created business to the some institution or organizations

5.0 Adaptation and adoption of CA

Local and international organizations have been responsible for introducing conservation agriculture technologies in the area. In 2004, FAO through CASARD applied a more organized and coordinated way to introduce the full package of conservation agriculture technologies through farmer field schools.

- **Adaptation**

Conservation agriculture adaptations in Karatu include changes farmers have made in their practices in the standard recommendations to suit their local socioeconomic, cultural, technical, agro-ecological and other local conditions. Generally, no farmer who has tried conservation agriculture innovations has abandoned them completely, but they have modified some technologies to suit their environment. For example, instead of crop rotation farmers have resorted to intercropping because of the shortage of land. Some households lost seeds through poor timing during planting and lack of adequate pest control, but they have sought other seeds to replace the lost ones to continue with the practices.

Increase in yield and having lablab as alternative cash and food crop has been the driving motivation for more farmers to join and continue with conservation agriculture. Farmers who have adopted conservation agriculture practices have modified their planting times and crop sequence. Instead of relaying cover crops (pigeon pea) with maize, they have decided to intercrop (planting at the same time). When Alfred found that leguminous cover crops tend to decompose rapidly, he opted to use finger millet residue to establish permanent soil cover. The practices of soil cover and crop rotation have been adopted simultaneously. Lablab in particular has been treated as a cash and food crop, and has been attributed with the ability to improve soil fertility. Hence, a group of about 10 farmers in Rhotia have set programmes to rotate lablab in infertile soils followed with maize, wheat, or finger millet. Most conservation agriculture practitioners bridge the missing support of inputs such as cover crop seeds and implement by seeking support from fellow farmers. However, the farmer field school approach has brought in much group dynamics, allowing more interaction between farmers and increased sharing of knowledge and resources.

- **Adoption**

Many youths (18–30 years) and some people 40–50 years were ready to adopt conservation agriculture technologies. Youths were eager because they are more business minded. However, lack of capital has prevented many from adopting them. Some youths don't have their own land or they have only a small area obtained from the parents; hence they are not motivated to invest in agriculture. Large-scale farmers (for example, Msituni Catholic Church Farm) were ready to take up such innovations as subsoiling, and in fact, they were not waiting for external encouragement or even support. With significant financial resources and high levels of literacy, innovative large-scale farmers quickly take advantage of innovations and the opportunities inherent within them. Inherent opportunities include potential reduction in the cost of production, risk reduction through diversification, soil fertility improvement, and maximization of yields.

6.0 Present challenges in Conservation Agriculture work

The challenges are drawn from the projects, which have tried to work on conservation agriculture technologies in Karatu so as to be a lesson and a model for new project interventions. The challenges are two: to promote conservation agriculture to farmers and to get them to adopt it. These challenges are so intermingled that it is not possible to separate them entirely (Richard *et al.*, 2007); the following are some of the few challenges affecting the practice of CA in Karatu district:

- **Project sustainability not ensured in many projects**

Project sustainability, through the beneficiary's ownership and capacity building in conservation agriculture technologies, has not been properly observed; consequently many project activities have ceased immediately after donor support phases out. This cessation can be attributed to several factors: failure to observe participation properly or to build community-based expertise, donor withdrawal premature, inadequate government or community support, inadequate marketing of cover crops, etc. Most projects were designed, implemented and analyzed by external facilitators, such as researchers, with minimal involvement of farmers; hence they lacked smooth continuity.

- **Inadequate coordination at the district level**

The different conservation agriculture stakeholders in Karatu are not well identified or coordinated towards achieving the set goals through tackling different objectives, such as introducing conservation agriculture technologies, following through to ensure adoption, diffusion and scaling up, assuring proper documentation, including a database of conservation agriculture activities. It is difficult to tell who did what, when and where, and what has been achieved.

- **Too much focus on individual farmers and lack of proper analysis**

Most of the previous efforts focused on individual, innovative farmers, and this to some extent hindered the fast spread of the technology. Except for the farmer field school approach, which has started only recently, community sensitization to create awareness and readiness to participate fully in conservation agriculture technologies was lacking or has been minimal. However, it seems that even the field schools did not properly carry out SWOT (strength, weakness, opportunities and threats) analysis of conservation agriculture technologies as an intervention to improve crop production. This probably explains why inputs, implements and local capacities were not properly considered.

- **Lack of implements in the district**

Conservation agriculture implements are not readily available at the district headquarters, and some are too expensive for farmers to buy. Local artisans are not well trained in how to make the required conservation agriculture implements.

- **Inadequate policy analysis and advocacy of related issues**

Few attempts have been made to analyze the policy environment of conservation agriculture or to advocate conservation agriculture technologies in national policy processes regarding agriculture and natural resource management. The district does not have an agricultural resource centre dealing with conservation agriculture technologies, inputs and implements, and it is difficult to depend on services from afar.

- **Problems of attaining permanent soil cover and weed control**

Weed management, especially in the initial stages of adoption of conservation agriculture, is a major problem. The main reason is that both cover crops and crop residue have other immediate advantages to the farmers and their families. Availability of rainfall, management of the soil cover and time of planting the cover crop affects biomass production.

- **Competition for livestock feeds and soil cover**

Approximately 90% of Karatu small-scale farmers practice mixed farming. Traditionally, crop leftovers are kept as dry season feed; it is almost impossible to leave crop residues as soil cover while animals are starving.

- **Weak bylaw establishment and enforcement**

Land rights are weak and the poorest farmers reported that it is difficult for them to claim their land rights because the process is cumbersome and the outcome uncertain. Enforcement of existing bylaws is weak; bylaws proposed by the community are long delayed before getting district approval.

- **Limited access to cover crop planting materials**

Many seed stockists sell seeds, mainly of maize, horticultural crops and sunflowers— but not cover crops. This is where the facilitating role of SARI comes strongly into play. The role could go as far as supporting new stockists with the supply of cover crop seeds in the villages where the demand is high.

- **Limited knowledge in agronomic practices for different cover crops**

Many farmers (about 250) were ready to plant multipurpose crops that can also provide food and cash. That means they need to abide by all agronomical practices—timely planting, use of certified seeds, proper spacing, weeding and pest control, proper harvesting and storage. That trend of knowledge is lacking so that farmers growing lablab and pigeon pea have being complaining about poor yields due to poor agronomical practices and postharvest loss due to poor storage.

Conservation agriculture technologies and practice require intensive knowledge and experience, which at present is not available locally. A functioning local network of conservation agriculture stakeholders in the district with good links to the centres such as Arusha is essential to keep knowledge sharing going among farmers.

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