Conservation agriculture (CA) in Tanzania: the case of the Mwangaza B CA farmer field school (FFS), Rhotia Village, Karatu District, Arusha

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This project was initiated to promote conservation agriculture (CA) in Tanzania so as to improve the food security and rural livelihood of small- and medium-scale farmers through the scaling up of CA as a sustainable land management (SLM) tool as well as increasing the numbers of SLM-CA farmer field schools (FFS) in communities. The project had two phases from 2004 to 2010. It was funded by a Government of Germany trust fund and implemented by the Food and Agriculture Organization of the United Nations (FAO) and the Ministry of Agriculture in Tanzania. The project pilot districts include Arumeru (Arusha & Meru Councils), Karatu, Babati, Hanang and Moshi districts. CA has been shown to offer positive elements that could contribute to fighting hunger and poverty.

Keywords: agriculture; conservation; cover crops; farmer; field; livelihood; ripping; school; soil health; sustainability

Introduction

It was 2006 when the farmers of Rhotia village, Karatu district made a turn from conventional tillage-based farming to conservation agriculture (CA) after realizing its benefits. Like small-scale farmers in other districts of Tanzania and other developing countries, farmers of Rhotia experience many production problems, low yields due to soil erosion being one of them. It is a common practice of farmers in Tanzania to graze or remove all crop residues from their fields after harvesting. This is a bad practice, which leaves the soil bare and susceptible to water and wind erosion. The top fertile soil is eroded over time, leaving unfertile and degraded soil for crop production. This, coupled with low use of organic or inorganic fertilizer, results in declining yields, leaving families with less food and money (GTZ Sustainet, 2006).

In 2004 when the CA for sustainable agriculture and rural development (CA SARD) project intervened in Rhotia village, farmers were taught about CA as a sustainable way of growing crops and managing soil health that conserves the soil and maintains or enhances soil fertility and productive capacity (Kassam *et al*., 2009). CA comprises three principles applied simultaneously, namely minimum soil disturbance, permanent soil cover and rotations/crop associations. Agriculture plays an important role in the economy of Tanzania as it contributes significantly to the country's gross domestic product (GDP); it accounts for 60 per cent of export earnings and employs 84 per cent of the rural population. Crucial components of the agricultural sector are food crops at 55 per cent of the total agricultural GDP, livestock at 30 per cent and traditional export crops at 8 per cent (URT, 2004a). In Karatu district, crop production and livestock production are by far the most important economic sectors, employing over 90 per cent of the labour force (Douwe and Kessler, 1997).

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INTERNATIONAL JOURNAL OF AGRICULTURAL SUSTAINABILITY 9(1) 2011
PAGES 1–8, doi:10.3763/ijas.2010.9108 ISSN: 1473-5903 (print), 1747-762X (online). www.earthscan.co.uk/journals/ijas

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Background information on Karatu district

Karatu district is one of the five districts in the Arusha Region, located in the northern part of Tanzania (Figure 1) between latitudes 3° 10′ and 4° 00′S and at longitude 34° 47′E. The district measures 3300km^2. Land use is classified as follows: arable land 102,573ha, pasture land 155,808ha, forest, bush and tree cover 61,218ha and Lake Eyasi 1060ha; Karatu district has four administrative divisions, 13 wards and 45 registered villages, Rhotia being one of them. The administrative headquarters is in Karatu town, approximately 150km west of Arusha town. It is an important stopover for most tourists heading for Ngorongoro and Serengeti national parks. The official population is 178,434 people (92,895 men and 85,539 women), growing at an annual rate of 3.2 per cent and aggregated into 33,000 households. The average population density is 52people/km^2 with low population in the western zone along Lake Eyasi (7–10/km^2) and higher densities (100/km^2) in Karatu and Mbulumbulu divisions (URT, 2004b).

The district has three physiographic zones, uplands, midlands and lowlands, with altitude ranging from 1000 to 1900m asl (above sea level). Rainfall in the district is bimodal; short rains fall between October and December and long rains between March and June (KDC, 2001). Rainfall ranges from less than 400mm in the Eyasi basin to over 1000mm in the highlands with rainfall zones classified as semi-arid (300–700mm/year) and sub-humid (700–1200mm/year), respectively (Meindertsman and Kassler, 1997). Soils vary depending on their origin and location in the landscape. Shallow degraded soils with low fertility are found on uplands of the inland valleys and on the slopes. Clay soils of moderate fertility are found in the valleys with gently rounded summits and on slopes overlying soft gneiss rocks.

Arable farming and pastoralism are the two kinds of land use. Farming is largely rainfed.

Background information on Rhotia

Rhotia village is one of the 45 registered villages in Karatu district. It has a population of 6698, of which 80 per cent depend on farming for their living. The altitude of Rhotia ranges from 1500 to 1600m asl and receives an average rainfall of 800–1500mm per annum (1997–2000 weather records). However, currently the village receives only 600–800mm of rainfall per annum due to climate change. The main crops cultivated by Rhotia farmers include maize, beans, *Dolichos lablab*, wheat, barley, pigeon pea, finger millet, sunflower, flowers and coffee. Farmers also keep livestock such as cattle, goats, sheep, donkeys and poultry. A total of 20 per cent (22 per cent) of livestock is stall fed. The major crop production problems faced include limited and unreliable rainfall, limited labour, soil erosion and low soil fertility. All these factors contribute to low crop production and hence food insecurity (hunger) and poverty in the village.

During the 2000 World Summit in Johannesburg, the German Government promised substantial assistance in achieving the Millennium Goal of halving hunger by 2015. Therefore, the German Ministry of Agriculture and the Food and Agriculture Organization of the United Nations (FAO) agreed on CA practices in Northern Tanzania as an appropriate set of interventions. In view of the above, in 2004 when the CA SARD project started, Karatu was chosen to be one of the pilot CA districts. This choice was based on the promising experiences with minimum and no-tillage and direct seeding through cover crops in Karatu district. To facilitate the promotion process the project enhanced the supply and availability of CA equipment to farmer field schools (FFS), by stimulating private sector participation in the manufacturing, retailing and hiring of appropriate equipment, including jab planters, ripper subsoilers, direct animal planters (DAP), zam wipes and rippers.

Project processes

The first phase (2004–2006) of the project covered three districts including Arumeru, Karatu and Bukoba. The dissemination approach used was the FFS, a group approach, developed earlier by FAO integrated pest management projects in Asia. A total of 31 FFS groups were founded, of which 10 were in Karatu district. The total 31 FFS groups comprised about 765 farmers. Together with some spontaneous FFS founded by farmers themselves, the total number reached 44 FFS at the end of the first phase. In the second phase (2007–2010), the project continued with scaling up of CA as an SLM (sustainable land management) CA FFS, not only in other pilot districts but also in Karatu. During its second phase, the project was extended to Babati, Hanang and Moshi districts and Meru council in Arumeru district and facilitated the formation of 86 FFS, making a total

of 130 FFS. Currently, the project reaches more than 3500 farmers (CA SARD, 2009).

When the project started, it provided training on CA concepts and FFS methodology to extension workers who became facilitators of the FFSs. The project also provided training to farmers on how to apply CA technologies/practices, which include the use and maintenance of CA implements, run FFS groups, etc.; the FFS groups were assisted with the startup CA equipment, which included subsoilers, rippers, jab planters, direct planters and zam-wipes. The FFS groups also received 10kg of maize seed, 8kg of *lablab*, a 1litre bottle of round up (glyphosate) and stationery (notebooks, pens, pencils, erasers, flip charts and marker pens).

Each group tested several CA options depending on their priority problems. The Mwangaza FFS tested five technologies (Table 1):

1. Ripped plot, planted with maize intercropped with *lablab*.
2. Ripped plot, planted with maize intercropped with pigeon pea.
3. Non-ripping plot, planted with maize intercropped with *lablab*.
4. Non-ripping plot, planted with maize intercropped with pigeon pea.
5. Farmer's normal practice; ploughing twice and then planting maize intercropped with pigeon pea, beans and pumpkins.

The plots were monitored by FFS members through their sub-groups; in-depth investigation and observations of crops and its surrounding areas were undertaken regularly from the beginning to the end of the season by agro-eco system analysis. Farmers used their own experience and observations to make decisions on how to manage the crop. Records of the type of work done, number of people per operation, time taken per operation, type of inputs, quantities/rates and cost were kept. Before harvesting, normally farmers hold a 'Field day' to show other farmers in the village/community what has been going on in their plots. Farmer assessment/evaluation of all tested technologies follows so as to know the most preferred technologies.

For the case of the Mwangaza FFS, the most preferred option was a ripped plot direct seeded with maize intercropped with *D. lablab*. It gave the highest yields of maize (3.75t/ha), conserved moisture and controlled soil erosion. The second most preferred option was a ripped plot planted with maize intercropped with pigeon pea, which also gave high maize yield, controlled erosion, high litters from dropping leaves and improved soil fertility), and the third most preferred option was a non-ripped plot, planted with maize intercropped with *D. lablab*. The farmer practice was the least preferred option due to its low yields, high cost and time of managing the crop.

On completion of the learning process, farmers graduate and receive certificates from the FFS organizer (CA SARD) and are then capable of starting new FFS as farmer facilitators. This was the case for Mzee Swalehe Shambani Swalehe who graduated from Umoja FFS and initiated Mwangaza FFS and Mwangaza B FFS. When the CA SARD project started, it was well received by the Karatu district council and the Rhotia village government. The village

Table 1 | **The CA treatments used by the FFS group for verification of the technology and yields**

No	CA technology tested	Maize yields in t/ha	*Lablab*	Pigeon pea
1	Ripped plot, planted with maize intercropped with *lablab* (maize; 300kg)	3.75	1.63t/ha	NA
2	Ripped plot, planted with maize intercropped with pigeon pea (maize; 260kg)	3.38	NA	0.75t/ha
3	Non-ripping plot, planted with maize intercropped with *lablab* (200kg)	3.50	1.00t/acre	NA
4	Non-ripping plot, planted with maize intercropped with pigeon pea	2.00	NA	0.75t/ha
5	Farmer's normal practice; ploughing twice and then planting maize intercropped with pigeon pea, beans and pumpkins	1.88	Beans 0.50t/ha	0.63t/ha

Note: Average yield in the village before CA ranged from 0.75 to 1.25t/ha

government enhanced village meetings from where farmer groups emerged. The collaboration was strengthened by the farmers who volunteered to give their farms for learning purposes. The village government strengthened by-laws that prohibited free grazing to ensure smooth learning of CA practices. The district council also facilitated farmers to conduct their field days and attend agricultural shows.

Together with the good collaboration with the district council, the CA SARD project worked with many partners including Selian Agricultural Research Institute (SARI) to strengthen CA research. NGOs including RECODA (Research Community and Organizational Development Associates), CPAR (Canadian Physician for Aids and Relief Services), WADEC (Women in Agriculture Development and Environmental Conservation) and CARE International collaborated for the purpose of speeding up the dissemination of CA technologies, build the capacity of extension workers as well as providing financial support to some of the beneficiaries. Other district councils, namely Arumeru, Babati, Hanang, Kilindi, Mbulu, Same, Monduli and Moshi councils, also participated to ensure the sustainability of CA technologies.

Mwangaza B FFS

The Mwangaza B FFS (Figure 7) is the 'daughter' of the Mwangaza FFS in Marera sub-village facilitated by Mzee Swalehe Shabani Swalehe (farmer-led facilitator). It was established in 2007 with 26 members with the main objective of upscaling the most preferred CA technologies and practices evaluated by Mwangaza FFS. Members constructed contour bunds to harvest and retain water, and plant cover crops including *D. lablab* and pigeon pea; they rotated maize with wheat and *D. lablab* with pigeon pea. Due to good training and self-learning in the FFS fields, farmers became knowledgeable and knew the methods of breaking hardpans through the use of sub-soilers or planting the deep-rooted pigeon pea. The group owns CA implements including a ripper, a sub-soiler and a direct planter. They do not have oxen but they hire them when they need.

The FFS members are very innovative because they stopped using herbicide during land preparation; instead they increased the population of cover crops and slashed it down during planting. Control of insects in *D. lablab* and pigeon pea is done through the use of a mixture of different herbs prepared by farmers themselves. Due to good management of soil, currently farmers of Mwangaza B are no longer using inorganic fertilizers. This has been replaced by the use of *D. lablab* and/ or pigeon pea, which fixes a significant amount of nitrogen (200kgN/ha).

In 2009 the group operated a communal field of 12 acres together, which was under maize + *D. lablab* + pigeon pea. Also 10 members had 1 acre each of the same crops under CA; the field was managed by all members. In addition the group members have all adopted CA on their farms and each member has trained three other farmers in CA. The income from the group farm was divided into two: 50 per cent is shared among the members and 50 per cent is reinvested in the group account.

Results from the Mwangaza B FFS adoption plot

During the 2009 cropping season, regardless of bad weather (drought) the group harvested a good maize crop with a better grain quality, big-sized kernels and big cobs that were well filled. This was a result of the efficient use of moisture by plants which was harvested by ripped lines in the field and conserved by cover crops. Conventional fields were greatly affected by drought, resulting in small and poorly filled cobs, small grains with poor quality and hence low yields.

When the members of the Mwangaza B FFS were trained, they were taught to use round up to kill the weeds before planting. However, through learning they discovered that they could do without herbicides by ensuring that the soil is continuously covered by crop residues and/or cover crops as well as by controlling weeds throughout the season by slashing and/or hand pulling.

The group observed the following: *D. lablab* as a cover crop softened the soil and changed it into darkish colour due to increase in soil organic matter. They also observed good water infiltration, increased worm population, reduced evaporation, improved soil fertility, etc. Farmers also reported that pigeon pea successfully breaks soil-hard pans.

Farmers realized that crop yield increased with time under CA. In 2009 season, which suffered from drought and additional elephant crop damage from the nearby conservation area, the Mwangaza B FFS harvested 20,000kg maize from the 12 acres (4.2t/ha) (Figure 8), 1800kg pigeon pea (375kg/ha) and 840kg *lablab* (175kg/ha) (Table 2). Q3

Table 2 | **Maize yield trend of Mwangaza B-adopted field**

Year	Yield bags/ha	Yield (t/ha)	Comments
2004	7.5–12.5	1.88–3.13	When started adopting CA
2006	22.5–35.0	5.75–8.70	
2009	50–60	10.50–17.5	Drought year

CA was effective in the fight against hunger and poverty (*lablab* or pigeon pea sell at 1100Tsh/kg). The yields under CA are generally higher and farmers noted that intercropping of maize with cover crops (pigeon pea and *D. lablab*) provided three harvests per season instead of two. They also learnt that the increase in crop production was brought about by improved soil conservation and water management under CA. Yields under CA increased from 1.25t/ha (2004) to 7.0t/ha (2009).

The farmers also experienced a reduction in labour and time requirements in farm operations after one season of CA. This was brought about by reducing the number of operations during land preparation (using rippers), planting (using direct planters), weeding (using cover crop + roughing), etc. Table 3 shows a reduction of labour and time for farm operations in the Mwangaza B Marera sub-village.

At the end of the first phase of CA SARD project, there were 765 farmers, practising CA in the northern zone. More farmers adopted during the second phase of the project within FFS groups, within and outside the groups to over 3600 farmers. For the case of Mwangaza B, each farmer trained three additional farmers, making a total of 104 in the Marera sub-village. About 400 farmers in the neighbouring villages including Gyekrum Lambo, Gyekrum Arusha, Ayalabe and Kilimatembo have also adopted CA from the Marera sub-village (CA SARD, 2009).

Table 3 | **Labour and time reduction under CA in Mwangaza B Marera sub-village**

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

CA technologies have been adopted on 7000 acres (2857ha) in the northern zone of which 600 acres are within and outside Rhotia village in Karatu district. The adopted technologies include pigeon pea 90 per cent of adopters, *D. lablab* 30 per cent, ripping 30 per cent and crop rotation 60 per cent (CA SARD, 2009).

In view of the above, it is predicted that the acreage and number of farmers adopting CA will triple by 2015 because they would have seen the benefits of CA from the early adopters. Normally individual farmers start adopting CA through small fields of less than 1 acre, but they expand the acreage as they become more knowledgeable on management of CA fields. For example, Mwangaza B FFS farmers in the Marera sub-village started with only 1 acre, but after two years they became experts on CA; they realized an increase in crop yields, reduced erosion and a reduction of time and labour requirements during their farm operations; therefore they decided to expand their CA field area to 22 acres. A saying in Kiswahili says 'kizuri chajiuza kibaya chajitembeza', which means (*Good thing sells quite easily; bad things have to be moved around with a lot of advertisement for them to be sold*). There is a sense that CA is now selling itself. Q4

When CA was introduced, farmers started using crop residues for soil cover, they stopped burning crop residues, they stopped removing crop residues from the fields or selling to farmers with livestock and the village government strengthened by prohibiting free grazing on their farms. This resulted in negative impact on pastoralists because they depended almost 80 per cent on crop residues for their livestock, especially during the dry season. This led to conflicts between CA farmers and livestock keepers in the areas where by-laws were not well established against free grazing.

CA brought the competition between crop residue as animal feed and as soil cover into sharp focus, thus creating awareness of the essential need for soil conservation from the beginning of the project. Before CA, tractor and oxen hirers had a good business of ploughing and planting (disc ploughs, ox ploughs, etc.) almost all the field conventionally, but when a few farmers changed to CA, the business was somehow reduced, because there was neither ploughing nor planting for them.

The same negative outcome affected casual labourers undertaking ploughing, planting and

weeding for conventional farmers, because now there
Q5 is no job for those who have adopted CA.
Q6 However, CA has positive social outcomes (Box 1) to adopters, including, firstly, more time for doing other developmental activities and thus getting more income, and secondly, more time to rest or socialize for both men and women. CA increased crop yields and increased income (sell surplus crop) and hence led to better housing and clothing, improved nutrition (increase in purchasing power for other HH domestic needs), etc. The positive social outcomes are quantified by a few members of Mwangaza B FFS in the Marera sub-village in Table 4.

The CA SARD project during its two phases aimed at spreading CA technologies and practices to other communities within and outside Tanzania through different methods. Where the technology was practised, it proved to be a promising technology for reducing food insecurity and poverty. The list below indicates the different ways that have been used by the project to share the benefits of CA with other stakeholders and community beneficiaries:
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- farmer-to-farmer informal visits
- field visits
- agricultural shows
- demonstrations
- farmer exchange visits (local, regional and international)
- advertisements, leaflets, posters and booklets
- radio programmes
- TV programmes
- training
- awareness creation, especially among policy makers (inviting them to world congresses)
- other meetings/workshops.

For the case of Mwangaza B FFS, they were visited by stakeholders from Tanzania and outside the country including government institutions, NGOs and visitors (from Kenya, West Africa, Mongolia, USA and UK). The CA practices adopted by Mwangaza B members also reached other farmers through their participation in different events like national and district agricultural shows, field days and meetings/workshops.

Farmer-to-farmer visits were commonly used by members to ensure effective dissemination of technology. Farmers who were interested in the technology were given 1–2kg of *D. lablab* to go and try it in their fields. Other farmers from nearby villages who required a large quantity of cover crop purchased it from the FFS group. These farmers came from Ayalabe, Geykrum Lambo and Kilimatembo.

During one of the field days conducted by the group, the Tanzania Independent Television (ITV) documented their activities, benefits and wildlife problems. After three years of practising CA, the Mwangaza FFS members are able to facilitate the formation and supervision of new FFS groups. When the West African trainees visited them, FFS members told them that they are capable of training them theoretically and practically on CA and the FFS approach.

Summarizing the story, the supervisors of the CA project (the first two co-authors) could say that the key elements of the processes and actions that built the system outputs and resilience include

- proper group formation, which led to sustainable and stable groups;
- proper problems analysis by farmers themselves, which gave possible solutions implemented by farmers using CA; and
- a participatory learning process through FFS was another key element that resulted in having a reasonable number of farmer-led facilitators who are very aggressive in spreading CA technology to other farmers.

The Mwangaza B FFS group, during implementation of CA practices, experienced a lack of equipment for faster spreading of CA and a lack of mechanized equipment for seeding wheat into residues and destruction of their field by wild animals (elephants). However, they are looking forward to purchasing a power tiller that will pull a CA direct seeder attachment. This will be used by their FFS group and

Box 1

"After three years (2005–2007) of practicing CA in my 3 acres farm, I have enough food and money to pay for my family's medical costs and children school fees. I also have enough time for fetching firewood and water. It is like a dream before I didn't know that one day My family will have this better life" Mama Angela of Marera sub-village in Rhotia village, Karatu district

Table 4 | **Livelihood improvement through CA adoption**

Farmer	Gender	Benefits that changed the lives of farmers
1	Male	• New iron roof • Increased acreage from 10 to 22 acres • Take my child to secondary school • Built a small modern house • Bought bicycle • Save money and food • Joined village community bank (VICOBA)
2	Female	• Enough food • Enough money for school fees and medication • More time to rest, fetch firewood and water • More time to socialize with other women in the village • Purchased cell phone
3	Male	• Enough food for the HH and sell • Build a business house • Build a garage – for hiring • More money, so keeps money in the bank • Purchased TV • Joined VICOBA • Enabled to service and maintain his small tractor which is giving hiring out services, for example carrying harvest, building materials, inputs, etc.
4	Male	• Food secured • Can send children to secondary school • Joined VICOBA
5	Female	• Food secured at the household level • Surplus crop to sell • A reasonable amount of money for clothing and school fees • More time to fetch firewood and water • Less debt; capable of paying for the requested service • More time to socialize • Balanced diet
6	Female	• Enough food • Enough money for school fees and medication • More time to rest, look after children, fetch firewood and water • Enough money for clothing • More time for other developmental activities and to socialize with other women

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individual FFS members and they will hire out the service to other farmers in the village and outside.

CA has been shown to offer positive elements that could contribute to fighting hunger and poverty. If more partners and farmers could join hands with the CA SARD project in the promotion of CA, this would make a major contribution towards combating climate change and achieving the Millennium Goal of halving hunger by 2015.

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