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Conservation Agriculture and Sustainable Crop Intensification in Karatu District, Tanzania

Cover photo:
The late Mzee Swalehe Shaban Swalehe, CA pioneer and lead farmer from Rhotia village, Karatu district (5th August 2011, in memoriam)

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Conservation Agriculture and Sustainable Crop Intensification in Karatu District, Tanzania

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FOREWORD

Plant Production and Protection Division (AGP) in the Agriculture and Consumer Protection Department has elaborated its vision and concepts regarding sustainable crop production intensification that follows an ecosystem approach in which the enhancement of output and productivity go hand-in-hand with the delivery of ecosystem services. This is elaborated in the book *Save and Grow: The New Paradigm of Agriculture* launched by FAO in July 2011 as a policymaker's guide to the sustainable intensification of smallholder crop production.

The theme of sustainable crop production intensification is also embedded in the Objective 'A' in FAO's strategic framework for enhancing food security, alleviating poverty and addressing other global challenges such as environmental degradation and climate change. Conservation Agriculture (CA) is considered to be a core element of FAO's strategy for sustainable production intensification, and more field projects dealing with small-scale farmers are introducing CA as an essential production system base for enhancing production of crops and livestock, livelihood and quality of life.

Future global food security relies not only on high production and access to food but also on the need to address the destructive effects of current agricultural production systems on ecosystem services and increase the resilience of production systems to the effects of climate change. CA enables the sustainable intensification of agriculture by conserving and enhancing the quality of the soil, leading to higher yields and the protection of the local environment and ecosystem services.

This report is about the CA for Sustainable Agriculture and Rural Development (CA-SARD) project in Tanzania funded by the German Government and implemented by FAO and the Ministry of Agriculture of the United Republic of Tanzania. The publication describes the experiences of introducing CA as a concept for sustainable crop production intensification in farming communities of Karatu District, Arusha Province, Tanzania. The case study explains the adoption process and shows the impact of CA in terms of agricultural production, environment and ecosystem services, livelihoods and other socio-economic factors. The case study is directed to policy makers, scientists and environmentalists and should help decision making towards sustainable intensification concepts for agriculture.

Shivaji Pandey
Director
Plant Production and Protection Division (AGP)

ACKNOWLEDGEMENTS

The financial support from the government of the United Republic of Germany to implement the Conservation Agriculture for Sustainable and Rural Development (CA SARD) project is gratefully acknowledged.

The project was carried out in the Karatu district in the Arusha region of the United Republic of Tanzania by the CA SARD Tanzania team based at the Zonal Selian Agricultural Research Institute, Arusha. The team is grateful to the Zonal Director, Dr. Ally S. Mbwana, for extending his full support to the project.

The facilitation, supervisory and backstopping roles of FAO (Food and Agriculture Organization), the Ministry of Agriculture and Food Security and Cooperatives and the African Conservation Tillage Network (ACT) during implementation of the project are acknowledged with much appreciation.

The project benefited from the whole team of FAO Tanzania, especially Dr. Loise Setshwaelo (FAO Representative), James Yonazi (Assistant FAO Representative), Gerald Runyoro (Programme officer), Rehema Marandu (Secretary) and Gabriel Mhina (Driver). Their technical, administrative and operational support to the project is thankfully acknowledged.

The extensive collaboration and untiring support received from the Extension Services in both Karatu District Council and Rhotia Village Council are acknowledged with grateful thanks.

Last but not least the active participation, commitment and keen interest of our beloved farmers in Karatu deserve special acknowledgement and gratitude. In particular, the efforts made by the late Mzee Swalehe Shaban Swalehe in promoting Conservation Agriculture, through facilitation of FFS groups, use of botanicals for pests and disease control, his contribution in CA promotion and adoption will always be remembered.

LIST OF FIGURES AND TABLES

ACRONYMS AND ABBREVIATIONS

ACT	African Conservation Tillage network
AESA	Agro-Eco System Analysis
ASDS	Agricultural Sector Development Strategy
CA	Conservation Agriculture
CAADP	Comprehensive Africa Agricultural Development Program
CA-SARD	Conservation Agriculture for Sustainable Agriculture and Rural Development
CPAR	Canadian Physicians for Aid and Relief
FAO	Food and Agriculture Organisation of the United Nations
FFS	Farmer Field School
GDP	Gross Domestic Product
HIV	Human immunodeficiency virus
IPM	Integrated Pest Management
NGO	Non-governmental organisation
NSGRP	National Strategy for Growth and Reduction of Poverty
PRSP	Poverty Reduction Strategy Paper
RDP	Rural Development Policy
RECODA	Research, Community and Organizational Development Associates
SARI	Selian Agricultural Research Institute
TZS	Tanzania shilling – valued at 1500 to USD 1 in this report
US$	United States dollar
VICOBA	Village Community Bank
WADEC	Women's Agriculture Development and Environmental Conservation

SUMMARY

Karatu district is one of five districts in Arusha Region, located in the Northern Zone of Tanzania. Agriculture plays an important role in the economy of Tanzania, contributing significantly to the country's GDP, accounting for 60 percent of export earnings and employing 84 percent of the rural population. Most smallholder farmers in the region grow maize, beans and pigeon pea, with some farmers able to cultivate rice and wheat and small scale vegetable production. Agricultural productivity in the district has decreased due to unreliable rainfall (erratic precipitation and lower annual totals) and poor soil fertility leading to a decline in yields and growing food insecurity amongst smallholder farmers. Heavy reliance on rain-fed crop production systems increases the risks faced from precipitation changes, highlighting the reality of climate change as a major threat to the livelihoods of smallholder farmers.

Since 2004 the Selian Agricultural Research Institute (SARI) has been promoting Conservation Agriculture (CA) techniques to smallholder farmers through the project known as Conservation Agriculture for Sustainable Agriculture and Rural Development (CA-SARD). The project objective was to improve food security and rural livelihoods and build a foundation for the expansion of conservation agriculture to contribute to agriculture and rural development through the use of Farmer Field Schools(FFS). This case study identifies four objectives of (1) protecting ecosystem services to enable sustainable crop production intensification and improved agricultural productivity; (2) contributing to secure livelihoods and reducing vulnerability through asset accumulation for smallholder farmers; (3) enhancing the social capital of small-scale producers with participation in farmer groups and access to networks; (4) creating an enabling environment for smallholder farmers to adopt conservation agriculture practices through the implementation of effective pro-poor policies and access to credit via local micro finance facilities like SACCO's, VICOBA etc.

In Karatu district, adoption of the three CA principles of minimum soil disturbance, permanent organic-matter soil cover and diversified crop rotations has protected and enhanced ecosystem services, contributing to sustainable agricultural productivity. This increased productivity has contributed to the accumulation of assets which enhance smallholders' potential to build sustainable livelihoods. Social capital is improved by smallholders' involvement in FFS which build relationships and trust in the community and encourages interaction with outside parties such as agricultural extension workers and NGOs including CPAR, Mazingira bora Karatu which can then be used to access further opportunities and information. CA adoption in Karatu district

has been successful because of the efforts of the (district council) government, NGOs and international institutions to create an enabling environment for smallholder farmers.

The key to the continued growth in adoption of CA by smallholder farmers in Karatu district and Tanzania lies in the expansion of FFS, Farmer led groups and their linkages with agricultural extension officers and NGOs. Although CA farmers have shown increases in production and an ability to build their asset base they have not as yet diversified into more lucrative off-farm income generating strategies, instead investing their money into livestock production. There is scope to train farmers to access off-farm opportunities through their experience with FFS. These farmer groups already have their individual identities, a build up of trust within the group and shared experience of working together on the demonstration plots. A transition from FFS being seen as training groups to small and medium enterprises (SME) could be facilitated with training from extension officers, NGOs and the private sectors and would enable these groups to become more focussed on effective income strategies.

CHAPTER 1

Overview of the case study

Background and context

- The role of agriculture in Karatu district and its relevance to livelihoods.
- Land and soil degradation leading to loss of agricultural productivity.
- The threat of climate change for smallholder farmers in Karatu district.
- The potential for conservation agriculture (CA) to address productivity problems.

Objectives and activities

- Objectives of conservation agriculture for sustainable agriculture and rural development (CA-SARD) and areas of focus in the case study.
- Activities performed as part of the CA-SARD project.
- Social, economic and political barriers preventing adoption of CA by smallholder farmers.

Details of the case study

- Approach and methodology used to gather information for the case study.
- Results of observations and workshops held with farmer field schools (FFS).
- Key stakeholders involved in the CA-SARD project and in the case study.

Impacts and analysis

- Protecting ecosystem services to enable sustainable intensification.
- Contributing to secure livelihoods through asset accumulation.
- Enhancing social capital through farmer groups and access to networks.
- Creating an enabling environment through pro-poor policies.

Conclusion

- Review of the main outcomes of the case study.
- Barriers faced and suggestions for future upscaling of CA in Karatu district and Tanzania.

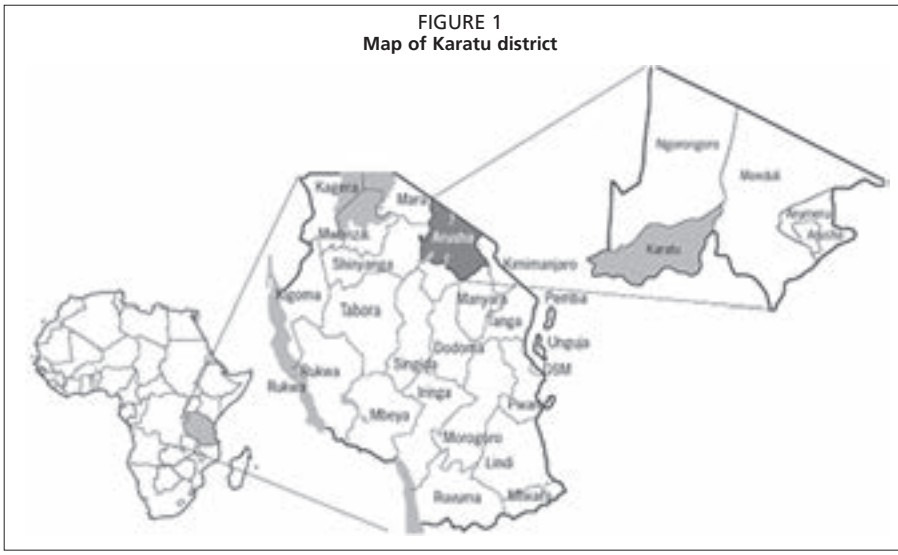
CHAPTER 2

Background and context

2.1 KARATU DISTRICT

Karatu district is one of five districts in Arusha Region, located in the Northern Zone of Tanzania (Figure 1). The district has three physiographic zones of uplands, midlands and lowlands, with altitude ranging from 1,000 to 1,900 metres. Rainfall in the district is bimodal; the short rains fall between October and December and the long rains between March and June (KDC, 2001). Annual rainfall may range from less than 400 mm in Eyasi Basin to over 1000 mm in the highlands with rain zones classified as semi-arid (300-700 mm/year) and subhumid (700-1200 mm/year).

FIGURE 1
Map of Karatu district



2.2 AGRICULTURE AND LIVELIHOODS

Agriculture plays an important role in the economy of Tanzania, contributing significantly to the country's GDP, accounting for 60 percent of export earnings and employing 84 percent of the rural population. 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). Most smallholder farmers in the region grow maize, beans and pigeon pea, with some farmers able to cultivate rice and wheat and small scale vegetable production. There are also large scale farms growing coffee, vegetables and flowers in fertile highland areas.

Agricultural productivity in the district has decreased due to unreliable rainfall (erratic precipitation and lower annual totals) and poor soil fertility (KDC, 2001) leading to a decline in yields and growing food insecurity amongst smallholder farmers. Declining yields lead to negative impacts on the livelihoods of smallholder farmers including decreased food intake and nutrition and a lack of income to invest in assets such as farm inputs, education for children and household improvements. This limits a household's ability to improve their livelihoods, fuels the cyclical nature of poverty and increases vulnerability amongst poor communities.

With a decline in the productivity and profitability of agriculture, households are searching for alternative means of income, a trend which is contributing to rural to urban migration. With many young people leaving farming in search of more profitable employment in towns and cities, rural farming populations are ageing leading to labour shortages on farms. This labour shortage is escalated by the impact of an HIV rate in Karatu of 20 percent, which is higher than the national average of 8 percent (Bishop-Sambrook *et al.*, 2004). Farmers affected by HIV/AIDS are unable to participate effectively in fieldwork leading to on-farm and household responsibilities being passed to other family members, often the elderly and children. Scarce resources are used to meet medical costs and households are often driven to sell assets of land, livestock and household possessions (Lyimo *et al.*, 2002). These labour shortages lead to problems such as a further decline in agricultural productivity, falling income, reduced purchase of farm inputs and children dropping out of school.

2.3 LAND AND SOIL DEGRADATION

In Karatu district, soil erosion and loss of fertility have been identified as major environmental constraints in both high and low altitudes. Contributing factors include expansion of farmland, agricultural mechanisation and continuous cropping which have all led to compaction of soils, nutrient mining, and erosion of soils due to water runoff and wind (Figure 2). Farmers often let animals graze crop residues (Figure 3) or burn them in the field after

FIGURE 2
Soil degradation from rain water and wind erosion

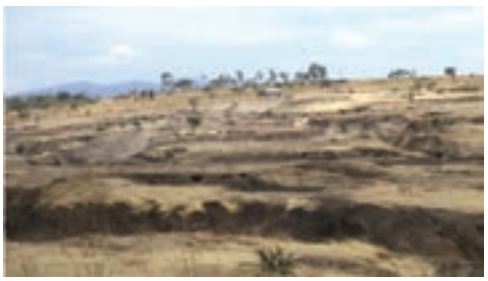


FIGURE 3
Grazing animals leave soils bare and unprotected

harvesting (Figure 4), leaving the soil bare and susceptible to erosion (Figure 5). Eroded soils unsuitable for crop production coupled with low use of organic or inorganic fertilizer, poor quality seeds and limited moisture leads to low crop production (Figure 6) hence food insecurity, low incomes and resulting poverty.

FIGURE 4
Burning crop residues in the field

FIGURE 5
Formation of gullies and poor soil quality due to erosion

FIGURE 6
Wilted maize as a result of limited rainfall and soil erosion

2.4 CLIMATE CHANGE

Heavy reliance on rain-fed crop production systems increases the risks faced from precipitation changes, highlighting the reality of climate change as a major threat to the livelihoods of smallholder farmers. In Tanzania, temperatures are predicted to rise by 2-4 °C by the year 2100 with dry seasons likely to be prolonged and availability of water for crops diminished (Paavola, 2008). By 2050, 350-600 million Africans are predicted to be at risk from increased water stress (Hahn *et al.*, 2009). In Karatu district smallholder farmers are already experiencing the effects of climate change. Average annual rainfall has fallen by approximately 100mm over the last decade (Figure 7) with rainfall days decreasing by 20 during the same period (Figure 8).

FIGURE 7
Average annual rainfall (mm) in Karatu district with trend-lines

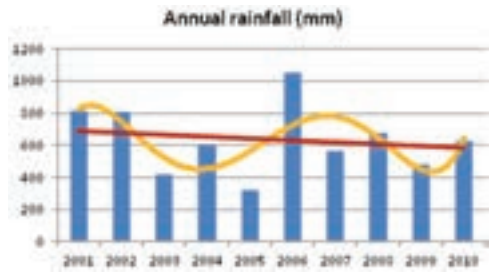
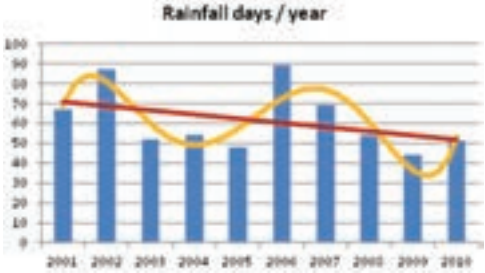


FIGURE 8
Rainfall days per year in Karatu district with trend-lines



2.5 CA-SARD

Since 2004 the Selian Agricultural Research Institute has been promoting conservation agriculture (CA) techniques to smallholder farmers through the project Conservation Agriculture for Sustainable Agriculture and Rural Development (CA-SARD). The project objective was to improve food security and rural livelihoods and build a foundation for the expansion of conservation agriculture to contribute to sustainable agriculture and rural development.

2.6 CONSERVATION AGRICULTURE

Future global food security relies not only on high production and access to food but also on the need to address the destructive effects of current agricultural production systems on ecosystem services (Foresight, 2011) and increase the resilience of production systems to the effects of climate change. CA enables the sustainable intensification of agriculture by conserving and enhancing the quality of the soil, leading to higher yields and the protection of the local environment and ecosystem services (Friedrich *et al.*, 2008). CA is based upon three key principles; (1) minimum soil disturbance, (2) permanent organic-matter soil cover and (3) diversified crop rotations.

Conventional tillage methods provide short term benefits for growing crops by loosening the soil, making a seedbed and controlling weeds however, over time this practice compacts soil, releases stored carbon into the atmosphere and speeds up the oxidation of organic soil matter (Kassam *et al.*, 2009). The consequences of this are decreased water absorption, soil erosion, loss of soil structure and nutrients, reduced organic soil matter, less biodiversity and ultimately falling crop yields.

A non-tillage approach involves the direct planting of seeds through mulch from previous crops, with as little soil disturbance as possible. By covering the soil with mulch it is protected from the effects of rain and wind erosion and provides a habitat for insects and bacteria which decompose the mulch and incorporate it into the soil (Friedrich *et al.*, 2008). Diversified crop rotation

is important for encouraging biodiversity, building up a diverse nutrient base in the soil and for pest management. Firstly, the rotation of crops with different root lengths will mobilise the existing nutrients and the selection of high biomass legumes will fix nitrogen from the atmosphere and enhance nutrients in the soil (Friedrich *et al.*, 2008). Secondly, by changing the available host plants, crop rotations will disrupt the lifecycle of some major pests and diseases that may have been encouraged by the permanent soil cover. These principles are aimed at enhancing natural biological processes above and below the ground so that the soil becomes potentially self-sustainable (Kassam *et al.*, 2009).

In Africa, CA has the potential of reversing the current annual 3 per cent decrease in agricultural production due to soil erosion and land degradation by providing more stability in crop production and better ratios of outputs over inputs (FAO, 2009). CA provides environmental services such as contributing to atmospheric carbon sequestration, preserving biodiversity, managing watersheds and preventing soil erosion (Fowler *et al.*, 2001). Communities and societies can also benefit from the adoption of CA through improved food and water security, more reliable water supplies (Fowler *et al.*, 2001) and protection of ecosystem services (Kassam *et al.*, 2009). In the context of labour constraints due to HIV/AIDS and rural migration to towns and cities, less labour intensive CA systems can leave farmers with more time to dedicate to other activities (FAO, 2009).

CHAPTER 3
Objectives and activities

3.1 OBJECTIVES

The overall objective of the intervention was to improve food security and rural development in Karatu district through the dissemination and implementation of conservation agriculture. This can be achieved through:

- Protecting ecosystem services to enable sustainable crop production intensification and improved agricultural productivity;
- Contributing to secure livelihoods and reducing vulnerability through asset accumulation for smallholder farmers;
- Enhancing the social capital of small-scale producers with participation in farmer groups and access to networks;
- Creating an enabling environment for smallholder farmers to adopt conservation agriculture practices through the implementation of effective pro-poor policies.

3.2 ACTIVITIES

Key areas of focus and related activities for achievement of the objective were to:

a. Create awareness amongst smallholder farmers of the benefits of CA:
   - Meetings were held with farmers to gather information on production problems and identify farmers who would be willing to form Farmer Field Schools (FFS), which are groups of 25 to 30 farmers (Figure 9).

b. Organise smallholder famers to enable effective dissemination and uptake of CA practices:
   - Training on CA concepts and FFS approach was provided to extension officers who became CA facilitators. After training, the extension officers facilitated the formation of voluntary groups, identified agricultural problems and possible solutions and involved the smallholder farmers in the selection of different methods to be tested by the FFS.

c. Train smallholder farmers on CA practices in a manner which encourages experimentation and learning:
   - Farmers were trained on CA principles and on the use and maintenance of CA implements for ripping, sub-soiling, direct planting and crop residue management (Figure 10).
   - Farmers were trained on the FFS structure and taught on how to use Agro-Eco System Analysis (AESA) tool.

FIGURE 9
Facilitation of FFS groups

FIGURE 10
CA implements training

- FFS groups tested four or five CA options on a one acre shared plot of land including (1) ripping with maize and lablab, (2) ripping with maize and pigeon pea (3) no-till with maize and lablab (4) no-till with maize and pigeon pea (5) normal practice of ploughing with maize intercropped with pigeon pea, beans or pumpkins.

d. Promote an environment in which farmers can share knowledge and experience:
   - Field days were organised for farmers to visit other FFS plots with the aim of sharing knowledge and experience with other people in the community.
   - After completing the learning-process farmers graduated and received certificates from the FFS organiser, after which the farmer is able to form a new FFS as a farmer facilitator.

e. Monitor the impacts of CA to assess the benefits to smallholder farmers:
   - Weekly monitoring of the shared plots by FFS members enabled a continuous learning process. Work done, number of people per operation, time taken per operation, type of inputs, quantities and costs were recorded.
   - Observation of crops and the surrounding area was continued throughout the season using AESA helping farmers to make decisions on how to manage crops on their own land.
   - Maize, lablab and pigeon pea were harvested from the shared plots followed by processing and weighing to identify the differences between the tested technologies. Cover crops were normally harvested two to three months after maize harvesting with management of cover crop continuing until land preparation for the next season.

f. Improve capacity of local manufacturers and retailers to supply CA inputs and tools:

- The project enhanced the supply and availability of CA equipment to FFS by stimulating private sector participation in the manufacturing, retailing and hiring of appropriate equipment including jab planters, rippers, sub soilers, direct animal planters and zam wipes.

3.3 SOCIAL, POLITICAL AND ECONOMIC BARRIERS

The concept of CA contradicts most of the farmers' rooted knowledge making it difficult to promote its benefits when compared with the most commonly used tillage based systems. Early-adopters of CA in Karatu were often perceived as being lazy because they left their land untilled and covered with residues. There is also a lack of general visibility of successful examples making communication of CA principles more difficult. In Karatu district the system of land tenure and grazing rights can also pose constraints to adoption and can only be overcome with the involvement of the entire community (Friedrich and Kassam, 2009). In the adoption process CA practices must be developed at a local level according to the agro-ecological conditions. Selection of crops to use in rotation and as cover crops, equipment, integration between crops and livestock, availability of key inputs, technologies and equipment must be developed locally working with indigenous farmers (Friedrich and Kassam, 2009).

Within an adequate framework of supporting policies farmers are far more likely to find an incentive to change from tillage-based systems to systems of sustainably intensified agricultural production. In Karatu district weak reinforcement of bylaws led to disagreements between farmers and livestock keepers surrounding the issue of crop residues being left in fields for soil cover rather than animal feed. Supporting policies need to intervene through legislation, regulations, credit provision, incentive programmes, research, development, information provision and training campaigns (Friedrich and Kassam, 2009).

Changing from tillage-based systems to CA involves long term investments from farmers of all farm sizes. Initial investments may be necessary to restore the soil as well as costs for new direct seeding equipment which can be a problem, especially for small scale farmers that do not have the available capital. The existence of financial service providers or the provision of credit might help to counter this constraint however these are often difficult to access for smallholder farmers.

CHAPTER 4

Details of the case study

4.1 APPROACH AND METHODOLOGY

The case study focuses on nine FFS based in five villages in Karatu district (Table 1). The case study draws on information gathered during the entire FFS process and observations of the activities described in section 3.2 of this report, primarily with Mwangaza B FFS in Rhotia village of Karatu district. Participatory workshops were also organised with FFS groups to gather feedback and opinions of the farmers. Workshop participants were selected due to their involvement in a CA-FFS, so sampling was non-probability with quota sampling setting a target of 100 smallholder farmer participants with equal proportions of females and males. Group workshops consisted of 10 to 15 smallholder farmers who all belonged to the same FFS. When participants were invited to attend, organisers arranged groups that represented the gender and age make-up of that particular FFS. In total, 52 female and 48 male smallholder CA farmers participated in the workshops (Table 2).

TABLE 1
List of villages and FFS used in case study

District	Village	Farmer Field School
	- Bassadowish	- Upendo
		- Juhudi
	- Getamock	- Tumaini
Karatu		- Alehhay
		- Mshikamano
	- Kambiasimba	- Tumaini
	- Kilimatembo	- Upendo
	- Rhotia	- Mwangaza B

TABLE 2
Workshop participants by research tool and gender

	Participatory Budget	Assets Focus Group	Ranking Exercise	Vulnerability Focus Group	Total
Female	1	26	7	18	52
Male	2	25	5	16	48
Total	3	51	12	34	100

Participatory tools used for gathering data in the workshops included:

- Participatory budgets to measure inputs and outputs for one acre of CA land;
- Focus groups investigating accumulation of assets and perceptions of vulnerability;
- Ranking exercises exploring the livelihood strategies used by smallholder farmers.

4.2 RESEARCH RESULTS

The participatory budget recorded the activities that a CA farmer carried out, how many hours each task took, the costs of inputs and income from outputs. Table 3 shows the monthly totals for each of these categories, showing that one acre of CA land generated US$400 of profit on top of maize that is reserved for family consumption.

TABLE 3
Expenditure and income for one acre of CA land

Month	Hours	Expediture	Income
Jan	63		
Feb	9		
Mar	8	56,000 (seeds and herbicide)	
Apr	24		
May	15		
Jun	2	9,000 (pesticide)	
Jul	5		
Aug	26	34,000 (shelling and bagging maize)	
Sep			
Oct	72	4,8000 (bags for lablab / pigeon pea)	400,000 (4 bags of pigeon pea
Nov	36		
Dec	6		300,000 (5 bags maize and ½ bag lablab)
Total	266 hours per acre	193,800 Tsh per acre	700,000 Tsh per acre

n.b.: This also generates 10 bags of maize (1 tonne) and 1 bag of lablab (120kg) for family consumption. This was for a family of seven so the amount of maize reserved for consumption and therefore profit made will vary depending not only on yield but on family size.

Participants in the asset accumulation workshops were asked whether certain assets had decreased, increased, or stayed the same since adoption of CA. Table 4 splits these assets into the five capitals of natural, social, human, physical and financial.

TABLE 4
Asset changes since adoption of CA

Capital	Change since CA adoption	Asset
Natural	Increased	-Yield of staple crops
		-Variety of crops grown
		-Retention of topsoil
		-Biological life in soil
		-Water infiltration into soil
		-Water retention of soil
		-Quality of soil
		-Quality of crops
	Decreased	-Incidence of weeds
		-Use of pesticide
	No Change	-Quality of drinking water
	Mixed response	-Use of chemical fertilizers
		-Use of manure
		-Use of herbicide
		-Incidence of pests
Social	Increased	-Interaction with other farmers
		-Involvement in community meetings
		-Time for other income opportunities
		-Time for rest or social purposes
Human	Increased	-Access to agricultural extension services
		-Child attendance at school
		-Nutrition of family diet
	Decreased	-Family members migrating to towns
Physical	Increased	-Availability of transport
		-Quality of roads
	Decreased	-Distance to nearest market
	Mixed response	-Quality of grain storage facilities
		-Quality of housing
		-Quality of latrines
Financial	Increased	-Ability to afford medicine
		-Purchase of household goods
		-Quality of seeds purchased
		-Access to credit services
	Decreased	-Quantity of livestock

The livelihood strategy ranking exercise was used to discover how farmers were generating their income and whether their livelihood strategies had changed since adoption of CA. Once all strategies had been discussed it was possible to discover which strategies were new, had been increasingly adopted,

were maintained, reduced or eliminated all together (Table 5). Figure 11 shows the strategies that generated the most income before and after CA adoption and Figure 12 shows the shift from time spent on arable farming before CA adoption, to livestock farming after CA adoption.

TABLE 5
Changes in use of livelihood strategies since CA adoption

Status of strategy	Source of Income	Before CA	Present
New	Maize surplus	0	12
	Lablab beans	0	12
	Selling pigs	0	6
	Selling manure	0	1
Increased	Selling chickens and eggs	3	9
	Using ox for land preparation and transport	2	7
	Selling milk (cow and goat)	3	6
	Selling cows	5	6
	Lentils	1	2
Maintained	Pigeon pea	12	12
	Selling goats/sheep	12	12
	Sunflower	12	12
	Finger millet	12	12
	Selling water	2	2
	Green vegetables	1	1
	Selling donkeys	1	1
	Reselling charcoal	1	1
Reduced	Selling firewood	5	4
	Making and selling rope	2	1
Eliminated	Casual labour	6	0
	Rock breaking for selling gravel	2	0
	Local brew	1	0

FIGURE 11
Change in most profitable income generating strategy since CA adoption

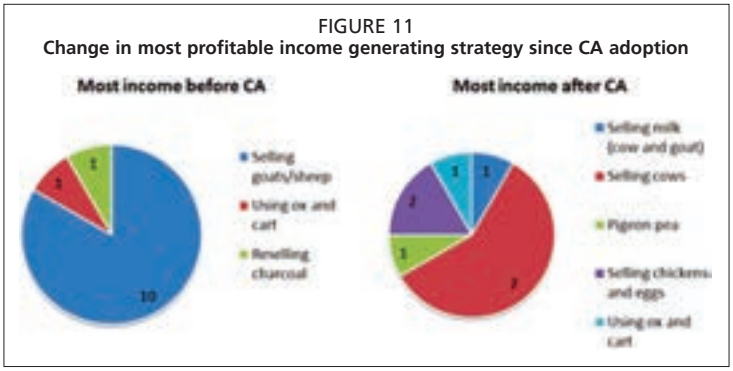
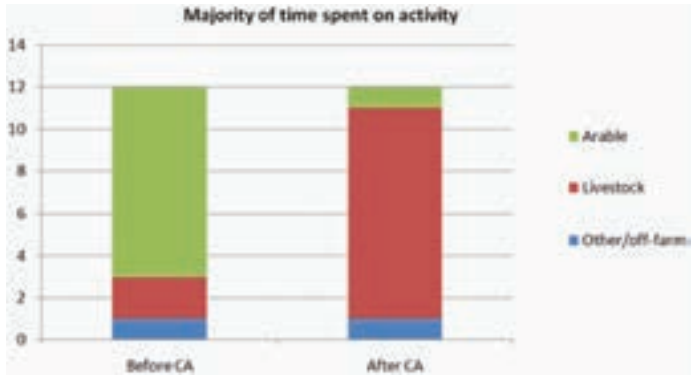


FIGURE 12
Majority of time spent on livelihood strategy before and after CA (number of participants)



To understand farmers' perceptions of their own vulnerability and resilience to shocks and stresses, the focus group explored what challenges they had faced over the last 40 years, how they coped with these challenges and how their response to such challenges has changed since adoption of CA. Table 6 shows some of the key discussion points that were mentioned during the focus group.

TABLE 6
Points discussed in focus group on perceptions of vulnerability

Q1. What challenges, in regards to food production, have you faced over the last forty years?		
Year	**Event**	**Details**
1974	Drought and pest outbreak	Livestock died and people ate dead livestock. Walking up to 100km to find food. People migrated with livestock but returned to village without livestock. People ate maize bran which was usually fed to cattle.
1984 / 85	Drought and pest outbreak	Food relief in the form of yellow maize provided by the US. Food relief was in exchange for work such as road construction, breaking rocks and collecting sand. Following year there was an outbreak of maize grain bore which villagers believe was related to the import of US maize.
1994	Drought	Similar to previous. Food for work schemes. Note decadal recurrence. Farmers mention the issue of climate change as droughts are no longer at ten year intervals.
2000 / 01	Drought and pest outbreak	People began shifting to towns to look for jobs, especially the young who dropped out of schools and searched for casual labour. Crop destroyed from caterpillar outbreak. Government introduced Maize Strategic Grain Reserve which aimed to buy maize from Tanzanian farmers and store for food aid so as to reduce foreign imports in times of low availability.
2009	Drought	Although the village was not too badly affected many Masai came to the area to graze their livestock. This created tension between communities and many of the Masai's livestock died in the area.
2011	Low rainfall and yields	Farmers were reporting reduced yields and expecting that the government would have to distribute food relief in the coming months.

Q2. How did you cope with these challenges?
- Migrate with livestock
- Migrate to towns in search of casual labour
- Sell animals – first chicken, then goats, then cattle
- Food rationing – dependence on government or foreign aid
- Get food or cash loans from wealthier families
Q3. What effect did these challenges have on you and your family?
- Children drop out of school
- Some male heads of household run away from family
- Women are left to care for and feed family
- If someone is sick they are left untreated as medicine cannot be bought
- Sometimes children were abandoned
Q4. Since using CA practices has your response to these challenges changed?
- Even with reduced rainfall, farmers still get yield compared to traditional practice which may get no yield
- Cover crops provide extra food and cash
- Not only change in yield but cost effective – "Even if you produce the same amount of yield you have spent less money doing so."
- Reduced livestock and more biomass makes it easier to feed livestock in periods of drought
- Milk from dairy cattle can be given to children or sold
- Now reserve 3 bags of maize per person for the following year in case of drought
- Village Community Bank gives access to credit

4.3 KEY STAKEHOLDERS

Farmers

- Key role in formation of FFS, and during length of process from land preparation to harvesting

Government

- Agricultural extension officers at district, ward and village level facilitating FFS formation and training on CA practices.
- District Council officials strengthened by-laws to reduce free-grazing
- National coordinators and facilitators at Selian Agricultural Research Institute (SARI) to provide technical advice and backstopping.
- Agro-mechanization Department of the Ministry of Agriculture Food Security and Cooperatives providing groups in six pilot districts with CA implements.

International institutions

- Food and Agricultural Organisation (FAO) providing financial assistance and technical advice.
- African Conservation Tillage Network (ACT) for monitoring and evaluation.

Non-governmental organisations (NGOs)

- Canadian Physician for Aid and Relief (CPAR) working in Karatu and Musoma district.
- Women in Agriculture Development and Environment Conservation (WADEC Tanzania).
- Research Community and Organizational Development Associates (RECODA) Tanzania which is currently supporting more than 82 FFS groups.
- CARE CA project has trained 30 CA FFS facilitators, established and procured inputs for 15 CA FFS.
- AGAKHAN FOUNDATION trained 35 facilitators to establish new CA communities.

CHAPTER 5

Impacts and analysis

Using the information gathered through the observation of activities carried out with FFS participants and the results from the research workshop on inputs and outputs, asset accumulation, livelihood strategies and vulnerability it is possible to assess the impacts of conservation agriculture on food security and rural development in Karatu district with special attention being paid to the four aims of:

- Protecting ecosystem services to enable sustainable crop production intensification and improved agricultural productivity;
- Contributing to secure livelihoods and reducing vulnerability through asset accumulation for smallholder farmers;
- Enhancing the social capital of small-scale producers with participation in farmer groups and access to networks;
- Creating an enabling environment for smallholder farmers to adopt conservation agriculture practices through the implementation of effective pro-poor policies.

5.1 PROTECTING ECOSYSTEM SERVICES

Ecosystems services describe the natural resources and processes that benefit societies and can be categorised into provisioning; regulating; supporting; and cultural services.

5.1.1 Supporting services

Nutrient cycling, soil formation, water cycling and provision of habitat are all forms of supporting services. In Karatu district, adoption of the three CA principles of minimum soil disturbance, permanent organic-matter soil cover and diversified crop rotations has improved these supporting services, contributing to sustainable agricultural productivity. Minimum soil disturbance has led to retention of topsoil and improved soil structure whilst nitrogen fixing cover crops such as lablab and pigeon pea have returned much needed nutrients to depleted soils. Dolichos lablab and pigeon pea fix approximately 200kg of nitrogen per hectare whilst avoiding water pollution through the use of fertilizers. Application of crop residues also provides a habitat for micro-organisms such as worms (Figure 13), which break down organic matter, adding to the nutrient cycle and creating natural tillage of soils, improving porosity, aeration and water holding capacity (Figure 14).

FIGURE 13
Earthworm populations per square metre on Mwangaza B FFS subplot

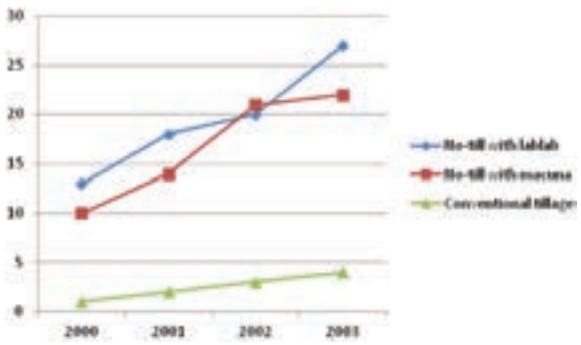


FIGURE 14
Biological tillage by earthworms

Water use efficiency has increased under CA conditions due to an improved water cycle of infiltration, holding and uptake. Organic matter soil cover (crop residues, mulch and cover crops) reduces water runoff and conserves moisture in the soil whilst the use of cover crops like lablab, radish and pigeon pea have deep roots capable of breaking the hard pan, therefore increasing the rooting depth and improving water uptake by the plant. The use of ripping on CA plots has also aided water use efficiency as the open furrow directs rainfall to the crop roots whilst also reducing erosion. Testament of the improved water use efficiency of CA come from farmers in Karatu district who continue to produce yields in years with limited rainfall, when the crops of other farmers using conventional tillage methods fail.

5.1.2 Regulating services

Regulation of climate, pests, diseases, erosion and natural hazards are all examples of regulating services. In Karatu district CA introduced preventive measures that reduced degradation through the construction of contour bunds, use of crop residues and elimination of tillage. These measures ensured the retention of fertile topsoil which was previously eroded through rainfall runoff and wind erosion.

The use of integrated pest management (IPM) and application of manure to replace chemical fertilizers has enhanced biodiversity and encouraged natural predators which have led to increased pest and disease regulation. Control of insects in lablab and pigeon pea was achieved through a mixture of different herbs prepared by farmers. Once sufficient crop cover has been established, use of herbicide is reduced as weeds are suppressed by cover crops, in turn reducing water pollution from agrochemicals. Farmers also stopped using herbicide during land preparation, instead increasing the population of cover crops and slashing this during planting time to be left as residue cover.

Although adoption of CA in Karatu district is not significant enough to regulate the climate it has enabled farmers to adapt to the effects of climate change. The usual ten year drought cycle of 1974, 1984, 1994 has been replaced by three droughts in the last decade. However, due to the water use efficiency of the CA system, adoptive farmers have at least harvested some maize during drought years compared to conventional till farmers whose crops have failed.

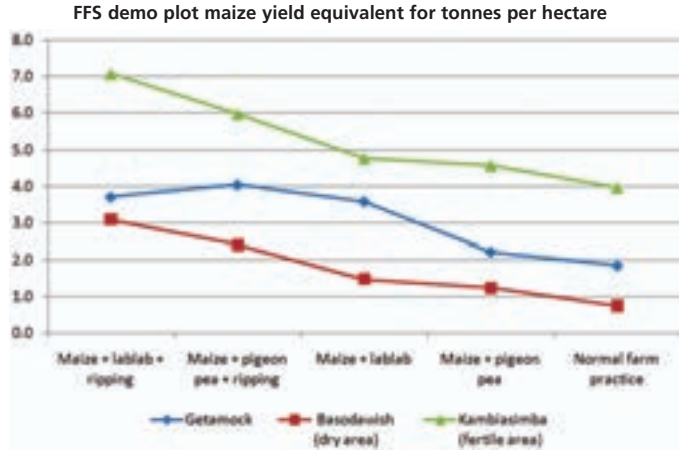
5.1.3 Provisioning services

Crops, wild food, fibre, fuels and fresh water are all examples of provisioning services. Farmers in Karatu district have demonstrated that through adoption of CA they have been able to protect and enhance aspects of these provisioning services. Crop production has increased as a result of implementing the three CA principles. Members of FFS are able to practice and observe CA techniques on a one acre demo plot which is split into five sub plots to help farmers visualise the difference in results and help them decide which techniques to transfer back to their own land. Yield results for each sub-plot are recorded and can be seen in Table 9 with Figure 15 showing what the yields for each of these 1/5 acre plots would represent in terms of tonnes per hectare.

TABLE 7
Maize yield from FFS demo plots (kg)

Status of strategy	Getamock	Basodawish (dry area)	Kambiasimba (fertile area)
Maize lablab ripping	300	250	574
Maize pigeon pea ripping	327	195	484
Maize lablab	290	120	386
Maize pigeon pea	180	101	370
Normal farmer practice	150	61	320

FIGURE 15
FFS demo plot maize yield equivalent for tonnes per hectare



There is a noticeable difference in yields between the subplots that utilize CA techniques and that of the normal practice of tillage, especially in the dry area (Basodawish) where yields quadrupled from 732kg to 3 tonnes per hectare, with the use of ripping.

Fuel, as a provisioning service has also been enhanced in Karatu district through the coupling of CA knowledge dissemination with information on agroforestry. Farmers that have planted trees as part of soil conservation measures are also able to prune and harvest these for firewood. As a result of higher yields leading to better incomes, some farmers have invested in household biogas production, using animal waste from their integrated farming systems to produce gas which can be piped directly to cooking stoves, minimizing the use of firewood and reducing exposure to harmful wood smoke.

5.2 CONTRIBUTING TO SECURE LIVELIHOODS

A livelihood can be defined as comprising "the capabilities, assets and activities required for a means of living" (Chambers and Conway, 1992). The term livelihood is often preceded by 'sustainable' which as Chambers *et al.*, (1992) explain, being one which "*can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation...*" Assessing impact on livelihoods therefore must take into consideration the assets owned by an individual, household or community and the activities by which these assets are gained, retained and protected.

5.2.1 Asset accumulation

Assets can be seen as the "building blocks by which the poor construct their own routes out of poverty" (Ellis *et al.*, 2003: p1372) and accumulation of these assets increases opportunities for poverty reduction. CA offers a number of ways of building the asset base of smallholder farmers and the first is by increasing efficiency of the production system by reducing inputs and increasing outputs. The participatory budget (Section 4.2) showed that major expenditure for CA plots included the purchase of seeds[1] and shelling and bagging costs[2]. Pesticides and herbicides were the only other expenses[3] bringing the total costs for one acre of CA land to approximately US$70.[4] Outputs included one tonne of maize and 120kg of lablab beans for family consumption plus 500kg maize surplus, 60kg of lablab and 480kg of pigeon

1 TZS 44,000 per acre (US$30) on maize, lablab and pigeon pea seeds.
2 TZS 38,400 (US$25) for 15 bags of maize and 6 bags of pigeon pea/lablab.
3 TZS 21,000 (US$14) for 400ml of pesticides and 1 litre of herbicides.
4 Total costs change depending on the yield, which for the year recorded was 15 bags (1500kg) maize per acre, as it was a fairly dry year. In good rainfall years, the yield increased to up to 25 bags (2500kg) per acre, therefore raising the shelling and bagging costs by Tsh2,300 (US$1.5) per bag.

pea which are sold, generating approximately US$470. The income generated from one acre of CA land not only depends on yield size, but also on family size and market prices.

The budget calculated that approximately 266 hours per acre per year are needed for CA land and a large portion of this is spent on contouring (which may not be necessary for all farmers), spreading manure, harvesting and threshing. Contrary to the belief that the time saved from the eradication of ploughing in a CA system is spent instead on weeding (Giller *et al.*, 2009), only 26 hours per year per acre (about 10 percent of total time) is spent on weeding and rouging. There are two main reasons for this, the first being that herbicide use in the early years of CA adoption make weeding more manageable. The second reason can be explained by the use of adequate crop cover which takes approximately two to three years to achieve. As well as fixing nitrogen, cover crops such as lablab suppress weed growth and reduce the need to spend money on herbicides in the long run.

Yields have increased and time is being saved, suggesting that the efficiency and productivity of the land has increased due to a higher output to input ratio than traditional faming systems. One farmer commented that "even if you produced the same amount of yield you would spend less money doing so" which shows that CA can help smallholder farmers to make better use of their resources to build capital. Smallholder farmers' perceived that their assets of natural capital had increased due to the eradication of the environmentally damaging effects of tillage. There was a noticeable increase in soil quality identified by the colour change, water retention and increase in biological life.

Financial capital has improved through an increase in yields enabling farmers to sell surplus crops. Families are now better able to afford medicine and purchase quality seeds. They also have better access to credit services through membership to VICOBA (Village Community Bank) enabling them to draw loans at low interest rates and without having to travel to the nearest town. Many farmers reduced their quantity of livestock, but were keen to communicate that they had increased the quality, often investing in dairy cows. The reduction of livestock is linked to the conflict of crop residue use between animal feed and mulching (Giller *et al.*, 2009) and whilst some farmers have migrated to keep their large herds, most farmers in FFS have seen the advantages of adopting CA and having a more manageable, sustainable and integrated livestock farming system. The conflict between livestock feed and mulching of residues has been resolved through the enforcement of bylaws that restrict free-grazing (Owenya *et al.*, 2011) and transferring fodder to tethered animals. Due to increased yields under CA systems, more biomass is produced so after the maize harvest farmers cut the stover, leaving about one metre from each plant in the field as residue and taking the rest for animal feed. This results in adequate soil cover and enough feed for livestock.

Accumulation of human capital such as education, skills and access to information and health services build the capacity of households to diversify their livelihood strategies and is key to promoting pro-poor growth in rural areas (Rigg, 2006). As well as an increase in child attendance at school, CA farmers also reported an increase in access to agricultural extension officers and a decrease in family members migrating to towns. Participants explained this decrease in migration as being linked to the increase in productivity of land due to CA and therefore people were returning from towns to work on small plots of land. An increase in yield has also led to better nutrition of family diets through increased consumption and more income to spend on other commodities such as vegetables, meat and fish. Medicine and medical costs can also be met more easily, improving the health of agricultural households.

Physical capital in the form of better quality roads and transport has increased since CA adoption. Although this may not be directly linked to the spread of CA practices, such as the investment in roads by the government, there are links between impacts of CA and the accumulation of physical capital. Some farmers claimed that because of the reduced rainwater runoff from fields as a result of CA, local roads are less eroded than they used to be. Better roads and the ability to purchase mobile phones has led to increased availability of transport services as farmers are now able to phone for motorcycle taxis to come to the village. Some farmers have improved the quality of their housing, upgrading from mud and thatch to concrete and iron houses with proper windows, making their living standards more comfortable and their houses more durable, reducing the frequency of repairs. Some have also managed to invest in solar panels and biogas which have benefits for households such as less exposure to harmful wood-smoke (Figure 16), access to information through radios, charging mobile phones at home rather than in the town and completing household tasks more easily after sunset.

FIGURE 16
Cooking stove fuelled by gas from household biogas plant

There exists a link between each of these capitals, with the accumulation of one asset providing an opportunity to gain another. All assets may not have been gained directly due to the adoption of CA but through the increase in natural capital as a result of the three CA principles farmers have gained opportunities to build financial capital and invest in human and physical capital.

5.2.2 Livelihood strategies

Livelihood diversification can be a means for a rural household to increase income, however, involvement in a diverse set of livelihood strategies doesn't necessarily mean a household is earning more income as often such strategies are used as coping mechanisms. The livelihood strategy ranking matrix (Section 4.2.) explored the strategies that CA farmers used before and after CA adoption. The most notable point was that farmers are now able to sell surplus maize, something that none of them did before CA adoption because yields were too low. The introduction of lablab as a cover crop also generated a new income source as lablab was not previously grown. Other new or increased strategies mostly revolved around livestock including selling cows, pigs, milk, chickens and eggs and this has only been possible because farmers gained income from selling maize, which they invested in livestock. Strategies that were either reduced or eliminated since the adoption of CA included casual labour, making and selling rope, breaking rocks to sell gravel and making and selling local brew. When asked why they had stopped using such strategies farmers replied that the tasks are so menial that they generate very little income and whereas before they tried everything they could to raise money they no longer needed to do these tasks because they had increased income from crops and livestock.

There is also a notable difference when investigating the strategies that created most income before and after CA adoption. Before CA, 10 out of the 12 farmers involved in the exercise generated most income from selling goats and sheep, whereas after CA adoption this strategy does not feature in the 'most income generated' list. After CA, selling cows featured highly and selling milk, chickens and eggs also featured. These findings support the necessity of building up a good agricultural base before livelihoods can be effectively diversified as "productivity increases in food crops ... release labour and capital... making them available for the production of higher value crops and non-farm activities such as manufacturing and services" (Jayne *et al.*, 2010). Research into the types of activities farmers spent most time doing also showed significant change with a big shift from arable farming to livestock. This can be attributed to the time saving properties of CA practices which are then spent on livestock duties, leading to better rearing practices and increasing the income generated from livestock.

5.2.3 Human and labour rights

The Karatu case study indicated that CA promotes human and labour rights because of decent distribution of labour by gender and reduced drudgery for women and children. In conventional tillage women and children were the main source of labour for planting, weeding, harvesting and processing. CA implements reduce labour demand, saving time on activities traditionally seen as women oriented. This means women are able to spend more time

on household duties or other income generating strategies such as vegetable production and small businesses. Table 9 indicates labour and time reduction under CA as experienced by Mwangaza B FFS members. Labour and time saving was a result of a number of techniques during land preparation (using rippers), planting (using direct planters), and weeding (using cover crop + roughing).

TABLE 8
Labour and time reduction under CA

Operation/acre	Conventional tillage		Conservation Agriculture	
	Time	Labour	Time	Labour
Land preparation	8 hours	4 persons	3 hours	2 persons
Seeding using Direct Animal Planter (DAP)	7 hours	6 persons	2 hours	2 persons
Weeding	2 days	4 persons	1 day	2 persons

5.3 ENHANCING SOCIAL CAPITAL

Social capital plays "a vital role in helping people act to improve their livelihoods, mobilise assets and defend them" (Bebbington 1999: p2034) and participants of the research believed their social capital had increased since adoption of CA through more involvement in community meetings, increased interaction with other farmers and more time for off farm activities and socialising.

5.3.1 Community participation

The FFS structure used to disseminate CA practices encourages farmers to participate in decision-making on issues that directly or indirectly affects them. The groups are facilitated by village and ward level government extension workers who not only train the farmers on CA techniques but on other topics such as livestock management and HIV prevention. Smith et al (2001: p431) comment that the success of such groups "has been characterised by experience, education and links gained outside of the community context ... benefiting from government, donor and NGO infrastructural investment in the districts." Involvement in CA FFS can therefore lead to the accumulation of social capital amongst the group members, which leads to further access and accumulation of assets.

In Karatu district, village authorities involved communities in the identification of priority production problems including drought, low soil fertility, low yields, food insecurity and soil erosion. Farmers then formed FFS groups to address the problems using CA techniques as the solution. The importance of involvement in these social situations became evident when farmers explained how through the FFS they also learned about health issues such as HIV, and discussed concerns such as the necessity to educate their

children. Previous barriers to education had been the need for children to look after livestock, some parents were worried that the school was too far away and some people thought education was not necessary as the children would work on the farm in the future. When these thoughts were shared and discussed in the group many farmers came to the conclusion that when they get old, their children take care of them so it would be a good idea if they are educated so they can earn a better income. This led to an increase in human capital among households as child attendance in schools has increased.

5.4 CREATING ENABLING ENVIRONMENTS

CA technologies have been adopted on 7,000 acres (2,857 ha) in the Northern Zone of Tanzania of which 600 acres are within Karatu district (CA SARD, 2009). Decisions made by smallholder farmers on the production methods they adopt are likely a result of multiple factors, some of which will be influenced by outside parties such as government institutions, NGOs and the private sector. If farmers are to be allowed to adopt new technologies that enhance agricultural production they need a "facilitating environment" (Ellis *et al.*, 2003: p1381). Such an environment however, is precisely what many smallholders lack with Friedrich et al (2008: p29) identifying barriers consisting of a lack of inputs, market access, infrastructure and pro-poor policies which restrict them from adopting new technologies or not benefitting accordingly once the new technology has been adopted.

5.4.1 Collaboration

A key role for the dissemination of CA techniques is that of the agricultural extension workers. Whether at district, ward or village level, it is their job to initiate the set up of FFS and train farmers on CA techniques on a demo plot, so that farmers can decide what methods to use on their own land. They are also responsible for training farmers on other topics such as livestock husbandry, credit schemes and tree planting and on social issues such as HIV and the importance of education. A major obstacle they encountered in their role was the slow adoption rate of CA outside of FFS which they attribute to the lack of CA equipment and also the challenges surrounding free grazing of livestock and the initial battle to get bylaws imposed which protect fields from wandering livestock (Owenya *et al.*, 2011).

Other government staff involved in the spread of CA include agronomists, researchers and communication staff at research institutes such as SARI. The CA-SARD facilitators at research institutes are responsible for linking stakeholders and coordinating the national approach for CA adoption. They advise extension workers and farmers on seed varieties and suitable cover crops, liaise with manufacturers for distribution of equipment and gather information from practising farmers on the benefits and constraints of CA. It is the role of the information and extension officer to increase coverage of

new technologies such as CA and repackage information in suitable formats for audiences including farmers, NGOs and policymakers. These messages are often disseminated through the mass media (radio and newspapers) and at agricultural shows.

NGOs carry out similar tasks to agricultural officers in respect to training and formation of FFS but also have the capacity to address non-agricultural enterprises such as set up of small businesses. NGOs are keen to mainstream issues of gender and environment into their practices, an area that may not be central to government extension workers' role. From the spread of CA, NGOs have noticed that yields have increased, time is being saved which opens up other opportunities for farmers and there is increased community cohesion as farmers are learning from each other leading to the breakdown of gender barriers. The private sector is involved through the manufacturing and provision of CA equipment such as rippers, direct seeders and hand-jab planters. Heads of local manufacturing companies have been on international visits to witness the production of CA equipment in areas where uptake is high. These companies then produce equipment at the request of agriculture extension staff that place group orders for FFS wishing to purchase the specialist equipment.

The spread of CA in this area is therefore an effect of the concerted efforts made by extension workers, researchers, NGOs and policy makers who are using CA to address issues of soil degradation and erosion to build the productivity of farms in an attempt to achieve food security for smallholder farmers. For members of FFS, CA adoption has been successful but for farmers outside of these groups adoption has been slower than would have been hoped. Stakeholders believe that continued upscaling requires more of the same with more FFS setup and training on CA practices and special topics such as livestock management, micro-credit and HIV.

5.4.2 Knowledge creation and validation

CA disseminated through the FFS structure promotes continuous learning and exchange of knowledge among farmers and different actors. When the CA-SARD project started in Karatu, public institutions and NGOs were not promoting CA techniques. These actors where encouraged to act as partners in training, farmer assessments, field days and exchange visits to help in sharing information and knowledge resulting in increased adoption of CA technology. By the end of the 1st phase of CA SARD project, there were 765 farmers practicing CA in the Northern Zone. More farmers learnt and adopted during the 2nd phase of the project, reaching a total of 3,600 farmers. In Mwangaza B FFS, each farmer trained 3 additional farmers making a total of 104 in 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).

5.4.3 Laws and policies

CA in Tanzania is aligned to the Agricultural Sector Development Strategy (ASDS) and the Comprehensive Africa Agricultural Development Program (CAADP) framework whereupon CA-SARD articulated its objectives along the CAADP pillars, which are Sustainable Land and Water Management; Market Access; Food Supply and Hunger; and Agricultural Research.

The two major constraints to CA adoption highlighted by all stakeholders included the crop residue issue and access to equipment. The first of these constraints has been well addressed with bylaws being enforced, livestock herds reduced to manageable levels and a transfer from free-grazing to zero-grazing practices. The issue of equipment however remains an issue for farmers and although many FFS own some equipment it appears there is still not enough for all farmers to complete timely field preparation. With manufacturing companies in the local areas having the capabilities to make CA equipment it is not the lack of availability that is the problem but instead a question of provision and affordability. With the government and NGOs providing some equipment at the FFS setup phase, many farmers have established a mindset of dependence or what Fowler *et al.* (2001: p103) label 'receiver mentality'. When asked about accumulation of capital farmers were quick to point out the improvements they had been able to make to their homes and the ability to send their children to school, but they were less willing to spend money on CA equipment.

Meeting costs of CA equipment is challenging for a rural household but from the gains it has been proven to produce, expenditure on equipment would soon recoup its costs. There is also scope for farmers to purchase equipment as a FFS group, splitting the costs between members, however, whilst farmers in FFS may be happy to learn techniques together there are less examples of collective action in sharing costs and collaborating on income generating opportunities. This presents a potential area for governments, NGOs and the private sector to train FFS in the future on the opportunities and practicalities of collective action.

5.4.4 Food security programmes

CA aligns with the national Food Security programmes such as the Tanzania Development Vision 2025 (TDV2025), the Poverty Reduction Strategy Paper (PRSP), Rural Development Policy (RDP), the National Strategy for Growth and Reduction of Poverty (NSGRP) and the Agricultural Sector Development Strategy (ASDS). All these strategic efforts recognize and prioritise agriculture and sustainable natural resource management as key development pillars in realising the intended acceleration in real GDP growth and the needed reduction in poverty for a significant portion of the population in Karatu district and Tanzania as a whole.

In 2009, a drought year, Mwangaza B FFS harvested a good maize crop with a better grain quality, large kernels and big cobs which were well filled. They harvested 20 tonnes of maize from five hectares of CA land (4t/ha), 1.8 tonnes of pigeon pea (360kg/ha) and 840kg lablab (168kg/ha). Given these yields, FFS members were food secure and made food available to those who had no harvest due to the drought. The district council did not request food aid for the village and did not purchase food from other villages or regions.

CHAPTER 6
Conclusions

6.1 OUTCOME OF ACTIVITIES

The overall objective of the intervention was to improve food security and rural development in Karatu district through the dissemination and implementation of conservation agriculture. To assess the success of the intervention this case study focused on the concepts of:

- Protecting ecosystem services to enable sustainable crop production intensification and improved agricultural productivity;
- Contributing to secure livelihoods and reducing vulnerability through asset accumulation for smallholder farmers;
- Enhancing the social capital of small-scale producers with participation in farmer groups and access to networks;
- Creating an enabling environment for smallholder farmers to adopt conservation agriculture practices through the implementation of effective pro-poor policies.

In Karatu district, adoption of the three CA principles of minimum soil disturbance, permanent organic-matter soil cover and diversified crop rotations has protected and enhanced ecosystem services, contributing to sustainable agricultural productivity. Minimum soil disturbance has led to retention of topsoil and improved soil structure whilst nitrogen fixing cover crops such as lablab and pigeon pea have returned much needed nutrients to depleted soils. Water use efficiency has increased under CA conditions due to an improved water cycle of infiltration, holding and uptake. Land degradation has reduced through the construction of contour bunds, use of crop residues and elimination of tillage. The use of integrated pest management (IPM) and application of manure to replace chemical fertilizers has enhanced biodiversity and encouraged natural predators which have led to increased pest and disease regulation. Farmers have been able to adapt to the effects of climate change as evident from the noticeable differences in yield between CA and conventional farmers in periods of low rainfall.

CA can contribute to the accumulation of assets which enhances smallholders' potential to build sustainable livelihoods. Through higher output to input ratios and the subsequent improved efficiency of land, smallholders can make better use of limited resources, improve yields and build financial capital through the sale of surplus crops. Natural capital is

gained through the application of the three CA principles which reverse the trends of degradation and erosion that have led to reduced yields. Through the generation of natural and financial capital, smallholders are able to invest in human and physical capital such as education for children, improved health through better nutrition and medicine, and household improvements such as more durable walls and roofing and purchase of solar panels. Under CA, productivity of land is restored reducing the need for smallholders to engage in menial income generating strategies such as casual labour and rock breaking. With the income gains made from higher yields, smallholders are investing in more lucrative livestock practices including dairy cows and chicken. Since CA adoption there has been a shift from the majority of time spent on growing crops to attending to livestock, highlighting the time-saving aspects of CA and the opportunity this creates to raise more income from livestock. Social capital is improved by smallholders' involvement in FFS which build relationships and trust in the community and encourages interaction with outside parties such as agricultural extension workers and NGOs which can then be used to access further opportunities and information.

CA adoption in Karatu district has been successful because of the efforts of the government, NGOs and international institutions to create an enabling environment for smallholder farmers. Stakeholders have contributed through dissemination of CA knowledge, loans of cover crop seeds, advice on improved maize varieties and provision of CA equipment. Together the stakeholders were able to overcome a major issue presented by the conflict of crop residue use by training smallholders on livestock management and the implementation and enforcement of bylaws protecting land from grazing. It is now essential that all stakeholders continue to work together to overcome the issues regarding affordability and provision of CA equipment through strategies that encourage farmers to invest in the specialist tools whilst avoiding the receiver mentality that can ensue from subsidy schemes.

6.2 LESSONS LEARNT

6.2.1 Critical factors that led to the success of the intervention

- Voluntary group formation which led to sustainable and stable groups;
- Problem analysis by farmers themselves which presented applicable solutions such as Conservation Agriculture;
- Skilled farmers and facilitators on CA practices;
- Initial provision of inputs including CA implements;
- Strong collaboration between actors in the value chain including farmers, agricultural extension workers, CA implement manufactures, and input suppliers;
- Realisation of short term benefits of CA by farmers who were experiencing problems of drought, labour, time, soil erosion and land degradation;
- Successful control of water erosion.

6.2.2 Factors which slowed down the speed of adoption

- Lack of adequate CA implements;
- Crop–livestock conflict due to weak bylaws;
- Inadequate knowledge of CA amongst extension workers;
- Lack of skilled people on the use and maintenance of CA implements;
- Lack of clear policy on promotion of CA;
- Lack of involvement between key actors/players in the CA chain;
- Lack of CA trainings in schools and colleges;
- Lack of proper market for maize and cover crops.

6.2.3. Suggestions

- Have a clear policy regarding Conservation Agriculture;
- Promoters of CA should work as a team and have close collaboration to enable them to align approaches;
- CA implements to be readily available at a reasonable price;
- National policy to mainstream CA in colleges;
- Promote awareness of CA using different approaches in order to reach a wide audience;
- Increase training to farmer trainers for sustainability of the technologies;
- Involve all stakeholders who are involved in the value chain: producer, input suppliers, implement manufacturers, farmer;
- Zero grazing by-laws to be strengthened in villages and district councils;
- Have well trained CA implement operators.

6.2.4. Practical conclusions

The key to the continued growth in adoption of CA by smallholder farmers in Karatu district and Tanzania lies in the expansion of FFS and their linkages with agricultural extension officers and NGOs. These groups help to develop skills and knowledge through training on agricultural production technologies and are an effective means for delivering wider development messages related to health and livelihood issues. The group scenario also contributes to greater trust between members, discussion on social issues within the community and a breakdown of gender barriers. Improvements in the yields of FFS members are being noticed by farmers who are not involved in such groups with requests being made for the formation of new groups and in some areas farmers are setting up their own FFS with the assistance and training from members of other groups.

This expansion of the FFS structure will help to spread uptake of CA but there is still more work to be done with FFS that have already been set up. Although CA farmers have shown increases in production and an ability to build their asset base, the research into livelihood strategies suggests that whilst most farmers have reduced the menial tasks they used as coping strategies, they have not as yet diversified into more lucrative off-farm income generating

strategies, instead investing their money into livestock production. There is scope for FFS members to build on their production gains by entering into food processing strategies to add value to their produce, which has been done in a few areas with FFS that are linked to more innovative NGOs. Processing can be difficult on an individual basis as costs of equipment and marketing act as a barrier, but with group structures like FFS already set up there is a viable path towards successful market entry for these smallholder farmers. Barrett (2007, p301) writes,

> "...interventions aimed at facilitating smallholder organisation ... and improving poorer households' access to improved technologies and productive assets are central to stimulating smallholder market participation and escape from semi-subsistence poverty traps..."

FFS already have their individual identities, a build up of trust within the group and shared experience of working together on the demonstration plots. A transition from FFS being seen as training groups to small and medium enterprises (SME) could be facilitated with training from extension officers, NGOs and the private sector and would enable these groups to become more focussed on effective income strategies. Facilitation is an important part of this process as the facilitators, be they government, NGOs or private sector, "provide information and technical assistance and build the capacity of a group to effectively engage in marketing activities" (Markelova *et al.*, 2009: p5). In a group situation, costs of specialist CA and processing equipment can be shared and bargaining power with buyers improved.

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Conservation Agriculture and Sustainable Crop Intensification in Karatu District, Tanzania

Future global food security relies not only on high production and access to food but also on the need to address the destructive effects of current agricultural production systems on ecosystem services (Foresight, 2011) and increase the resilience of production systems to the effects of climate change. CA enables the sustainable intensification of agriculture by conserving and enhancing the quality of the soil, leading to higher yields and the protection of the local environment and ecosystem services. The present publication describes the experiences of introducing Conservation Agriculture as a concept for sustainable crop production intensification in farming communities of Karatu District, Tanzania. The case study explains the adoption process nad shows the impact of Conservation Agriculture in terms of agricultural production, environment and ecosystem services, livelihoods and other socio economic factors. The case study is directed to policy makers, scientists and environmentalists and should help decision making towards sustainable intensification concepts for agriculture.

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