

Conservation agriculture: a Uganda case study

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Uganda

Pilot initiatives to introduce more sustainable farming practices are many in Africa, but documentation of them is scarce.

Yet signs indicate that understanding is growing among farmers, stakeholders, researchers, and policymakers that sustainable agriculture is based on a few simple principles. These principles can be adopted to local climates and soil qualities as well as to varied technological and socio-economic factors.

Conservation agriculture provides such a set of principles. It is one of the most promising ways of implementing sustainable agriculture while minimizing the environmental degradation that is all too common on the African continent.

It relies on three basic principles: 1) minimum soil disturbance or if possible, no tillage at all; 2) soil cover— permanent, if possible; and 3) crop rotation.

This book is one in a series of case studies on conservation agriculture with examples from Ghana, Zambia, Uganda, Kenya and Tanzania, published by the African Conservation Tillage Network (ACT) and the French Agricultural Research Centre for International Development (CIRAD).

ACT, a pan-African association, encourages smallholder farmers to adopt conservation agriculture practices. It involves private, public and non-government sectors: farmers, input suppliers and machinery manufacturers, researchers and extension workers—all dedicated to promoting conservation agriculture.

Financial and material support for the case studies came from the Food and Agriculture Organization of the United Nations (FAO), CIRAD, and the Regional Land Management Unit (RELMA) of the World Agroforestry Centre (ICRAF).

ISBN: 9966-7219-2-4



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Design and layout: Conrad Mudibo

Printer: KulGraphics, Nairobi

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Correct citation:

Nyende, Paul; Nyakuni, Anthony; Opio, John Peter; Odogola, Wilfred. 2007. *Conservation agriculture: a Uganda case study*. Nairobi. African Conservation Tillage Network, Centre de Coopération Internationale de Recherche Agronomique pour le Développement, Food and Agriculture Organization of the United Nations.

ISBN: 9966-7219-2-4

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Abbreviations

AEATRI	Agricultural Engineering and Appropriate Technology Research Institute
AESA	Agro-EcoSystem Analysis (monitoring tool)
CA	conservation agriculture
FAO	Food and Agriculture Organization of the United Nations
FFS	farmer field school
NAADS	National Agricultural Advisory Services
NARO	National Agricultural Research Organisation
PDCO	participatory diagnosis of constraints and opportunities
RELMA	Regional Land Management Unit, supported by Sida and recently affiliated with the World Agroforestry Centre (ICRAF)
Sida	Swedish International Development Cooperation Agency
SLM	sustainable land management
ULAMP	Uganda Land Management Project

Preface

Pilot initiatives to introduce more sustainable farming practices are many in Africa; thorough documentation of results and lessons learned is scarce. Yet signs indicate that understanding is growing among practising farmers, stakeholders, researchers, and to a certain degree, policymakers, that sustainable agriculture bases itself on simple core principles. These principles, making use of natural processes, can respond to local climatic conditions and soil qualities as well as technological and socio-economic factors and conditions. Conservation agriculture is one of the most concrete and promising ways of implementing sustainable agriculture in practice. It relies on three basic principles: 1) minimum soil disturbance or if possible, no-tillage seeding; 2) soil cover: if possible, permanent; and 3) useful crop rotations and associations.

Across Africa, interest is growing to adapt, adopt, and apply these principles to attain agricultural performance that improves productivity and protects the environment—it sustains environmental resilience.

The French Agricultural Research Centre for International Development (CIRAD), the Food and Agriculture Organization of the United Nations (FAO), the Regional Land Management Unit in the World Agroforestry Centre (RELMA) and the African Conservation Tillage Network (ACT) have jointly facilitated this case study series to verify and document the status and effect of pilot initiatives on conservation agriculture with focus on sub-Saharan Africa. Eight case studies from five countries—Ghana, Kenya (2), Tanzania (3), Uganda, Zambia—are published in this series. A joint synthesis publication with overall results, lessons learned and recommendations for Africa is forthcoming.

It is our intent this series will be a source of information on conservation agriculture in Africa. It throws light on controversial issues such as the challenges farmers face in keeping the soil covered, in gaining access to adequate no-tillage seeding equipment, in controlling weeds, and on the challenges projects and institutions face in implementing truly participatory approaches to technology development, even as it illustrates the benefits of systems based in conservation agriculture and the enthusiasm with which many stakeholders are taking it up.

Bernard Triomphe, CIRAD

Josef Kienzle, FAO

Martin Bwalya, ACT

Søren Damgaard-Larsen, RELMA

Acknowledgements for Uganda study

We greatly appreciate the assistance and openness of the countless farmers (women, men, youth, elderly) who participated in the field studies. We equally acknowledge the sincerity of ward and district extension staff members and their contribution.

Special thanks go to all case study teams for their sincere efforts and sustained dedication to this work: Tom Apina, John Ashburner, Frédéric Baudron, Philip Boahen, Elimpaa Kiranga, Flora Kola, Charles Leseyo, Catherine W. Maguzu, Wilfred Mariki, Saidi Mkomwa, Claire Mousques, Ndabhemeye Mulengera, Ahaz Mussei, Remmy Mwakimbwala, Philip K. Mwangi, Herbert M. Mwanza, Njumbu, Anthony Nyakuni, Paul Nyende, Wilfred Odogola, Kennedy O. Okelo, John Peter Opio, Marietha Owenya, Dominick E. Ringo, Frank Swai, Paul Wamai.

The external reviewers who worked with the teams contributed generously with their input, support and direct interaction—Sally Bunning, Theodor Friedrich, Pascal Kaumbutho, Brian Sims, Kurt Steiner, David Watson. Their help we gratefully appreciate.

Special thanks go to the Ministries of Agriculture of Ghana, Kenya, Tanzania, Uganda and Zambia, who supported this work by granting access to their staff and the information in their jurisdiction.

Only through funding from FAO and CIRAD and the main institutions behind ACT and RELMA have the studies and this publication been made possible: the German Government through the FAO CA-SARD project, the Swedish International Development Cooperation Agency (Sida), and the Global Forum for Agricultural Research (GFAR).

Thanks to the technical editing and production team—Helen van Houten with Dali Mwagore, Keta Tom, Kellen Kebaara, Conrad Mudibo—who took on the task of assisting the case study teams and the series editors in going the ‘last mile’ towards publication.

Case study project background and method

Bernard Triomphe, Josef Kienzle, Martin Bwalya, Soren Damgaard-Larsen

This case study presents the status of conservation agriculture in Uganda. It is one in a series of eight case studies about conservation agriculture in Africa, which were developed within the framework of a collaboration between CIRAD (French Agricultural Research Centre for International Development), FAO (Food and Agriculture Organization of the United Nations), RELMA-in-ICRAF (Regional Land Management Unit of the World Agroforestry Centre) and ACT (African Conservation Tillage Network).

This introductory section outlines the overall background of the conservation agriculture case study project and the key methodological choices made. It also gives a brief overview of major results and observations across all case studies. This broad perspective allows the reader to appreciate both the commonalities among the eight case studies and the specifics of the one being presented here.

Conservation agriculture: a working definition

‘Conservation agriculture’ has been defined differently by different authors. Perhaps the most generic definition is the one provided by FAO:¹

CA is a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. CA is based on enhancing natural biological processes above and below the ground. Interventions such as mechanical soil tillage are reduced to an absolute minimum, and the use of external inputs such as agrochemicals and nutrients of mineral or organic origin are applied at an optimum level and in a way and quantity that does not interfere with, or disrupt, the biological processes.

From this definition, we can infer that conservation agriculture is not an actual technology; rather, it refers to a wide array of specific technologies that are based on applying one or more of the three main conservation agriculture principles (IIRR and ACT 2005):

- reduce the intensity of soil tillage, or suppress it altogether
- cover the soil surface adequately—if possible completely and continuously throughout the year
- diversify crop rotations

Ideally, what we call ‘conservation agriculture systems’ comprise a specific set of components or individual practices that, combined in a coherent, locally adapted sequence, allow these three principles to be applied simultaneously (Erenstein 2003). When such a situation is achieved consistently, we speak of ‘full conservation agriculture’, as illustrated by the practices of many farmers in southern Brazil (do Prado Wildner 2004; Bolliger et al. 2006) and other Latin American countries (Scopel et al. 2004; KASSA 2006).

1 FAO conservation agriculture website: <http://www.fao.org/ag/ca/index.html>

Full conservation agriculture, however, is today rarely practised outside South America (Ekboir 2003; Derpsh 2005; Bollinger et al. 2006), and is indeed difficult to achieve right from the onset. Usually farmers who are willing, or obliged by circumstances, to reassess their farming practices and follow the path to more sustainable agriculture, embark on a long journey that takes them several years or even longer. This journey consists of consecutive phases, each characterized by use of specific practices that increasingly incorporate practice and mastery of the three principles. No journey appears to be linear, and no journey seems to comprise the exact same sequence of phases (fig. A), although some paths are more commonly followed than others.

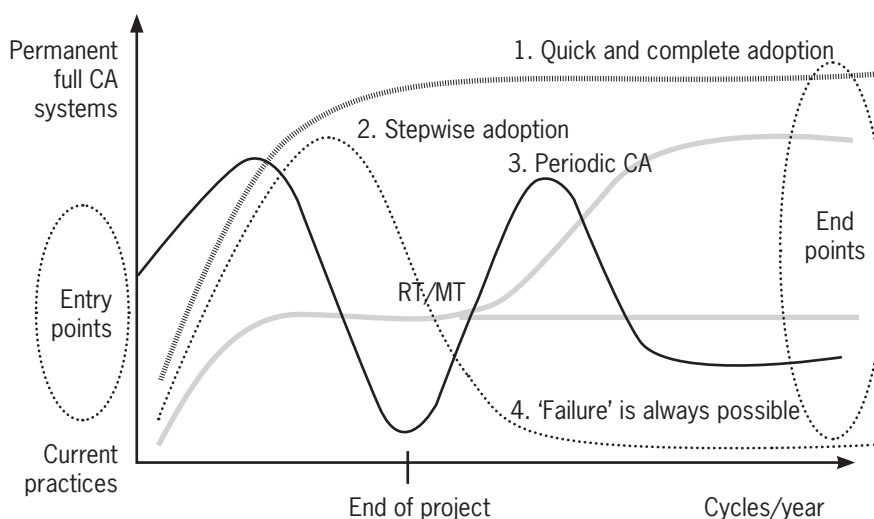


Figure A. Entry points and four hypothetical pathways towards adopting conservation agriculture:

1. Quick and complete adoption of conservation agriculture in its fullest form
2. Stepwise adoption of conservation agriculture practices, which may or may not lead to complete adoption over time (RT = reduced tillage, MT = minimum tillage)
3. Conservation agriculture practised during some cycles but not others
4. Use of conservation agriculture practices stops soon after the end of the project, perhaps because incentives are no longer available.

While the hope of many farmers and agronomists is that eventually most farmers in a given region will reach the full conservation agriculture phase, and better sooner than later, no phase in itself, no individual conservation agriculture system or set of practices can be considered intrinsically superior to the others (Triomphe et al. forthcoming).

Rather, they should be viewed as what can realistically be achieved at a given time and in a given farm context, depending on the environmental, socio-economic, institutional and political circumstances and constraints. Some factors and conditions clearly relate to the characteristics, preferences and experiences of individual farmers and farms—such as the capital available for investing in equipment and inputs, the choice of

cover crops, the soil conditions prevailing at the time conservation agriculture is being introduced, the care with which a farmer applies inputs or controls weeds, or the ability to learn new practices and take risks (Erenstein 2003). Others, however, relate more to the local or regional environment of the farm: ease of access to equipment, inputs and relevant knowledge, links to markets, existence of policies favouring (or discouraging) the adoption of conservation agriculture practices, and so on.

Given this huge diversity of adoption pathways, we use the term ‘conservation agriculture’ in this booklet with a meaning as general and open as possible, trying to refrain from judging if some actual practices were ‘real’ or ‘good’ conservation agriculture, while others were ‘partial’ or ‘poor’. Rather, we have made every effort to understand and explain what motivates farmers to try specific conservation agriculture practices, or what prevents them from trying the practices or from achieving success with them. At the heart of this assessment lies our desire to distinguish between conservation agriculture in theory (as promoters of conservation agriculture would like it to be implemented), and conservation agriculture in practice (as farmers are eventually able, or willing, to implement it).

Background

Why it was necessary to develop case studies

Rigorous documentation of successes, failures and challenges related to conservation agriculture adaptation and adoption is still rare, especially outside of South America. Also, most existing case studies have been written without relying on a unified systemic analytical framework, and hence are difficult to compare one with the other. They furthermore often demonstrate a strong bias towards emphasizing what is going well, overlooking process issues and problems encountered.

Under these conditions, the FAO working group on conservation agriculture and CIRAD decided to join forces in 2004 to contribute to a balanced documentation of conservation agriculture experiences and to better networking internationally. They were soon joined by RELMA-in-ICRAF and ACT, which had been actively involved in promoting conservation agriculture in eastern and southern Africa (Biamah et al. 2000; Steiner 2002; IIRR and ACT 2005) and which were also core partners in organizing the Third World Congress on Conservation Agriculture, which took place in October 2005.

Objectives

The overall objective of the conservation agriculture case study project was to strengthen collaboration among a number of key stakeholders who were preparing the Third World Congress on Conservation Agriculture, by improving understanding of past and current conservation agriculture experiences, and by improving networking among key stakeholders, with special emphasis on Africa.

Specific objectives for the case studies:

- Develop a framework for rigorously analysing ongoing conservation agriculture projects² and experiences and for characterizing in a holistic way

² The word ‘project’ is used in this context with an inclusive meaning, as it can refer to individual ongoing projects in a region or a country, or to a succession of projects having

how conservation agriculture practices are adapted and adopted and their effect.

- Develop a number of contrasting conservation agriculture case studies by applying this framework in selected regions.

The aim was to provide the resulting outputs to conservation agriculture practitioners, scientists and decision makers, so that they could contribute to improving conservation agriculture project planning and implementation.

What does a case study entail?

Here, a case study is a short-term, mostly qualitative study that synthesizes experiences and results obtained by applying and using conservation agriculture principles and technologies in a specific region in past or ongoing efforts and projects. It is developed around a unified, locally adapted framework focusing on conservation agriculture techniques and processes, on key issues and lessons learned, as well as on shortcomings and successes.

Majors phases of the case study project

The case study project on conservation agriculture began in late 2004 (table A). Following agreement on an analytical framework in February 2005, most of the fieldwork was developed during March–September 2005 by small teams of project personnel based in the study site, with guidance from the project coordinators. Early results and preliminary products were presented at the Third World Congress on Conservation Agriculture, held in Nairobi in October 2005 (Boahen et al. 2005; Baudron et al. 2005).

In the first half of 2006, drafts of individual case studies were developed through an iterative review process. The review culminated in a workshop held in Moshi, Tanzania, in August 2006, during which case study leaders and conservation agriculture resource persons worked together to further improve the drafts and compare results among case studies. The final step in developing the case studies, during the last quarter of 2006, involved a new round of editing in interaction between a team of editors and case study leaders.

Key methodological choices

Case study framework

The framework was developed in several stages. It integrated a series of previously identified issues, such as those developed under the auspices of programmes such as the Direct Seeding, Mulching and Conservation Agriculture Global Partnership programme³ of the Global Forum for Agricultural Research (GFAR), WOCAT⁴ and Sustainet.⁵ A major milestone for framework development was the workshop held in Nairobi in February 2005, which made possible direct interaction between the coordinators of the case study project and the future case study leaders.

taken place in one region or country over time, or to a number of projects operating simultaneously in one given region or country.

3 Website: <http://agroecologie.cirad.fr/dmc/index>

4 Website: <http://www.wocat.org/>

5 Website: <http://www.sustainet.org>

Table A. Milestones of the case study project on conservation agriculture

Date	Product, activity, output
Late 2004	Preliminary case study selection, draft framework developed
February 2005	Start-up workshop with selected team leaders for the case studies; agreement on the framework
March–Sept 2005	Activities for developing the case studies in the various sites, including midterm reviews in Kenya, Tanzania and Ghana
October 2005	Preliminary results reported as posters, papers and oral presentation during Third World Congress on Conservation Agriculture, Nairobi, Kenya
March–July 2006	Review and revision of individual case study drafts
August 2006	Workshop on cross-analysing cases and discussing their publication
Oct–Dec 2006	Final editing of individual case study documents
Early 2007	Case studies published as books and booklets

Eventually what became the reference framework for this project, guiding case study development, was a list of questions and issues structured under six main headings (see appendix 4 for details):

- biophysical, socio-economic and institutional environment of conservation agriculture farming systems
- historical review of work related to conservation agriculture in the selected site, region or project
- specific technologies, packages or systems being promoted, and how they differ from existing practices and systems
- overview of adaptation and diffusion process towards conservation agriculture
- qualitative overview of impact and adoption, in its agronomic, economic and social dimensions
- key gaps and challenges in site-specific circumstances

Using this overall framework, each case study team selected and adapted the issues most relevant to their own conditions and circumstances. Similarly, they developed their own guidelines for interviews and workshops. Thus the actual application of the framework remained specific to each case study.

Selection of case studies

Since this project could develop only a handful of case studies at the time, it was important that criteria for selecting them be clear. They included:

- demonstrated strong local interest for participating in a case study and helping develop it, and particularly local commitment for allocating staff time and resources such as transportation and communication for related activities
- overall value the case study would add towards addressing key issues related to conservation agriculture, particularly in extracting original, worthwhile

lessons on how its technologies performed, on ways they are diffused and adopted, and on links to sustainable agriculture and rural development⁶

- existence of at least a minimal body of local documentation on work related to conservation agriculture, from which a case study could be built
- complementarities with ongoing documentation efforts—preference often being given to situations for which no previous reports were available
- existence of a minimum trajectory of adaptation and diffusion, including evidence of some initial effect among farmers using conservation agriculture⁷

Based on a combination of these criteria, and following agreements reached among key stakeholders, 11 case studies were eventually selected (table B), out of which 8 were selected in Africa. More than half were directly linked to ongoing projects operating in eastern Africa.

How case studies were developed

The case studies were developed following an approach that presented a number of prominent features.

- It emphasized collaboration between insiders (local project staff) and a number of outsiders (case study coordinators and resource persons).
- It focused on a qualitative assessment of selected key issues and questions, based on participatory rural assessment techniques (interviews with key informants, collective workshops with selected stakeholders), which made it possible to collect testimonies.
- It relied on available evidence as found in project reports and documents.

Within these overall methodological choices, the specific steps and procedures followed to develop a case study included the following:

- Form a local case study team, typically comprising three to six members, usually practitioners involved in promoting local conservation agriculture.
- Develop a detailed work plan.
- Identify and collect local formal and grey literature about past or ongoing conservation agriculture activities in the region.
- Identify resource persons and institutions to serve as key informants.
- Hold interviews and workshops with key informants and stakeholders; observe conservation agriculture plots that farmers and farmer groups have implemented.
- Organize a mid-term review involving the local case study team, resource persons and project coordinators:
 - Review progress, difficulties, and preliminary findings.

6 The selection of cases was, however, not limited to ‘success stories’; some of the sites experienced or still are experiencing difficulties. The important point was what useful lessons could be gained from looking at what had happened so far.

7 Since it usually takes decades before large-scale adoption occurs, few potential case study sites would have witnessed it. Hence projects were selected that were just beginning to adopt (and thus were still significantly dependent on the project), provided that the technologies were already being tested at commercial scale under farmers’ conditions.

- Agree on priority activities for completing the case study and on adjustments needed in the original work plan, framework or methods.
- Identify concrete products to be presented during the Third World Congress on conservation agriculture (Nairobi, October 2005)
- Make a number of field visits to discuss with farmers and farmer groups and observe conservation agriculture experiments and demonstrations.
- Write up the case study draft.
- Prepare and present preliminary outputs for the Third World Congress on conservation agriculture (posters, oral presentations, papers).
- Develop the case study document in interaction with external reviewers.

The results obtained within the context of each case study outline an emerging but as yet incomplete picture about conservation agriculture in a given site. The case studies are qualitative in nature and relied principally on field observation. The case study teams had only some three to five months in which to compile their information. Their access to quantitative data was often limited. At times team members found it quite difficult to separate their role of critically assessing how conservation agriculture was functioning from their normal role as promoters of conservation agriculture.

The evidence the teams uncovered, however, is a major step forward. The findings are broadly consistent with the experiences and perceptions of most stakeholders and resource persons, and as such, they provide a legitimate, unrivalled view of present successes, challenges and the way forward. The studies are furthermore quite useful in pointing out to which specific areas and issues future projects should direct their efforts.

This book focuses on a specific case study. A number of results and lessons, however, can be drawn from a cross-analysis of all eight case studies selected. Such an analysis offers a unique opportunity to look at key technical and process issues and will be the focus of a separate publication.

The cross-analysis will summarize the information available to assess conservation agriculture practices implemented by farmers and their effects on crop productivity and profitability, and on labour use. It will discuss adoption trends. It will examine the approaches used to develop and promote conservation agriculture practices and systems, including the roles stakeholders, farmers' associations and the farmers themselves play in the process. It will analyse the extent to which adequate policy support is in place. In it, the following topics receive special attention. Preliminary comments follow.

First-hand observations

Tillage intensity

All types of tillage intensities are found across case studies: from minimum tillage to ripping to actual no-tillage. Most case studies highlight a number of difficulties farmers face when abandoning conventional tillage. It seems many do not go directly to no-tillage, and rely instead on reduced tillage as an intermediate step, if only because of restricted access to no-till seeders. This applies to case studies in Arumeru, Karatu, Laikipia and Zambia.

Table B. Key characteristics of case studies selected in Africa

Country, region	Climate / type of farmers	Experience with CA	Adoption status	Supportive project	Team leader
Kenya					
Laikipia	Semi-arid highlands / small- and large-scale, manual and animal traction	> 10 yrs (large), 2–3 years (smallholders)	Growing adoption (large), incipient (smallholders)	CA-SARD Kenya	Tom Apina, Paul Wamai, CA-SARD
Siaya	Humid lowland / small, vulnerable households, manual agriculture	3–5 years	Incipient	CA-SARD Kenya	Philip Mwangi, Kennedy Otieno, CA-SARD
Tanzania					
Karatu	Semi-arid to sub-humid, highland / manual agriculture	Late 1990s / early 2000	Incipient	CA-SARD Tanzania	Dominick Ringo, RECODA
Arumeru	Semi-arid to sub-humid, manual agriculture, highly degraded soils	Late 1990s / early 2000	Incipient	CA-SARD Tanzania	Catherine Maguzu, RECODA
Mbeya	Semi-arid / smallholders, manual and animal traction		Incipient	FAO-TCP	Saidi Mkomwa, ARI Uyole, TCP
Ghana					
Brong Ahafo, Ashanti	Rainforest transition / smallholders, purely manual agriculture	> 10–15 years	Significant but stagnant	FAO-RAFA / RELMA	Philip Boahen, consultant
Uganda					
Pallisa, Mbarara, Mbale	Humid to sub-humid / smallholders	3–5 years	Incipient	FAO-TCP	Paul Nyende, consultant
Zambia					
Southern Province	Semi-arid / smallholders, manual and animal traction	> 10 years	Large-scale, increasing adoption	CIRAD-WWF, ASP	F. Baudron, CIRAD- WWF, H. Mwanza, ASP

ASP – Agricultural Support Project (Sida funded), Zambia; CA-SARD – Conservation Agriculture for Sustainable Agriculture and Rural Development (FAO, sponsored by Germany), CIRAD – French Agricultural Research Centre for International Development; FAO – Food and Agriculture Organization of the United Nations; FAO-RAFA – FAO Regional Office for Africa; RECODA – Research, Community and Organizational Development Associates; RELMA – Regional Land Management Unit of the World Agroforestry Centre; SARI – Silian Agricultural Research Institute, Tanzania; TCP – Technical Cooperation Project (FAO sponsored); WWF – World Wide Fund for Nature

Soil cover

Providing adequate soil cover is a cornerstone of conservation agriculture. Yet most farmers face great difficulties in achieving it. Farmers tend to collect residue or allow livestock herds to graze freely on crop residue. This may be an individual decision, or it may be the result of agreements and traditions regulating the relationships between farmers and pastoralists, such as with the Maasai in northern Tanzania. Producing enough biomass to cater for both, adequate soil cover and livestock demands is a challenge. Replacing a food legume used traditionally in intercropping (such as beans) by a cover crop (such as canavalia or mucuna) might not be attractive to a farmer whose primary objective is achieving food security. This may explain the success that *Dolichos lablab* is having with Kenyan and Tanzanian farmers, as it is a multiple-purpose cover crop, able to provide food (both grain and leaves are edible), income, forage and soil cover.

Weed control

Weed control remains a challenge, especially when farming is done manually. As most farmers do not manage to keep their soils adequately covered, reducing tillage tends to increase aggressive weed growth. Controlling weeds adequately, which is critical to avoid crop failure, requires hoeing numerous times⁸ or using herbicides such as glyphosate. For many farm families, neither option is feasible. Labour resources are scarce or expensive, or access to herbicides and sprayers is restricted. More efforts are definitely needed to identify suitable cover crops and to achieve soil cover if herbicide dependency is deemed undesirable.

Equipment and inputs

Reduced tillage implements such as rippers and no-till seeders have been made available to farmers on an experimental basis. Often implements are imported from Brazil. Farmers are also being helped to get specific inputs, such as herbicides and cover crop seeds. Many farmers have restricted access to both implements and inputs; thus they are likely to delay planting, which adversely affects yield and income.

Family labour is increasingly scarce. This situation should ultimately lead to technologies such as reduced tillage systems, direct seeding technologies, herbicides, weed wipes or sprayers that save labour, although many farmers may not find them accessible or affordable.

Large-scale adoption of conservation agriculture practices requires a functioning input supply chain. This means both private and public sectors must play a more pro-active role in developing local capacity for manufacturing and making available appropriate implements and in devising innovative implement-sharing schemes (hire services, Laikipia) and adequate rural finance systems. Empowered farmers groups are perceived as being the right entry point for making inputs and services available.

⁸ For example, in southern Zambia conservation agriculture promoters recommend weeding four to six times.

Overemphasis on field-scale, technical issues?

Many projects and teams tend to focus on technical issues such as tillage, cover crops, weed control and implements at the field scale. This focus often implies less attention is given to non-technical issues, for example rural finance, marketing and value chain development, organizational or policy issues.

Farmer groups

The role of government institutions and publicly funded projects is essential. Case studies in northern Tanzania and Kenya emphasize participatory approaches, in particular farmer field schools. Early indications are that these field schools are a cost-effective way of participatory training. Groups of 10–30 farmers engage in collective and individual experimentation and learn conservation agriculture principles and practices. Beyond the issue of groups, projects and institutions can potentially develop more participatory and responsive approaches, with farmers more clearly in control.

Indigenous knowledge and innovative technology

Indigenous knowledge compatible with the principles of conservation agriculture is widespread across case study sites. Such is the case for the ‘proka’ slash-and-mulch system in Ghana, and for the farmers who are knowledgeable about the benefits of cereal-legume intercrops.

Ongoing projects tend to undervalue indigenous knowledge. One reason may be that conservation agriculture champions are keen to transfer external knowledge and innovative technology packages as a means of replicating the success stories that evolved in southern Brazil over a period of decades. Another reason is the tendency to perceive more the negatives of local traditions and farmer practices, such as grazing rules, without trying to understand the reasons for them. Tapping into indigenous knowledge and farmer innovation combined with imported innovative technology could well prove important in the long run.



This booklet now focuses on the situation of conservation agriculture in Uganda. It illustrates precisely some of the successes, and some of the challenges, that farmers and conservation agriculture projects alike face in their efforts to understand and implement conservation agriculture.

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Acknowledgements for Uganda study

This study was developed under a multiple partnership, supported by the Food and Agriculture Organization of the United Nations (FAO) in collaboration with the National Agricultural Research Organisation (NARO), Africa 2000 Network, a non-governmental organization; the Faculty of Agriculture at Makerere University; and the Sida-supported Uganda Land Management Project/Regional Land Management Unit (ULAMP/RELMA). Other important partners were the local governments of Mbale, Pallisa and Mbarara Districts, as well as the farming communities at the catchment sites of Busano and Busiu in Mbale, Sapiri and Petete in Pallisa, and Bisheshe in Mbarara District.

The project was supported by both the FAO office in Uganda and the Agriculture Department at FAO headquarters in Rome. Special thanks go to Sally Bunning (Land and Plant Nutrient Management Service) and Josef Kienzle (Agricultural and Food Engineering Technologies Service) for their support throughout the Technical Cooperation Project and, together with Bernard Triomphe of CIRAD, the case study coordinator, for their technical input in preparing this case study. Many thanks go to the various consultants who contributed useful materials during their missions in Uganda. Lastly, special appreciation goes to Abdul Kokas of KOKAS Excel Ltd., whose committed effort made the production of a video documentary of this case study possible.

Executive summary

This case study presents experiences and lessons learned from two pilot conservation agriculture projects implemented in three districts of Pallisa and Mbale in eastern Uganda, and in Mbarara in south-western Uganda. Conservation agriculture was introduced in Uganda through two pilot projects, a FAO Technical Cooperation Project (TCP/UGA/2903) in eastern Uganda in 2002 and a Sida-funded project in western Uganda in 2000. Conservation agriculture activities were piloted in contrasting microcatchments that represent areas where land degradation is accelerated. The pilot projects introduced smallholder farmers to conservation agriculture principles through farmer field schools that emphasized the integral nature of improved land management and livelihood strategies. Projects focused on demonstrating how conservation agriculture principles could be applied in Uganda, illustrating their multiple benefits in terms of productivity (labour saved, income augmented, diversity of products), sustainable use of natural resources (biodiversity and resilient land-use systems), and environmental services (better water quality, reduced costs of erosion).

This case study, conducted between March and September 2005, involved 32 farmer field school groups and incorporated views of various stakeholders such as research and extension personnel who promoted conservation agriculture in the region.

Practices introduced and promoted included minimum tillage with the use of herbicides; direct planting using a jab planter, *jobbe*, and ripper planter; permanent planting oblong holes, permanent raised beds; slash-and-mulch without burning; and the use of cover crops such as mucuna, lablab and canavalia.

Results show that conservation agriculture positively affected crop yield, labour use, timeliness of field operations, weed control and farm incomes. Major challenges were encountered in adapting some of the conservation agriculture equipment such as knife-rollers and jab planters, assuring availability after the project closure of conservation agriculture tools and cover crop seeds and planning for diffusion of the successful technologies.

The conservation agriculture initiatives through the pilot projects yielded commendable achievements. There was evidence of farmers' eagerness to learn, adapt and adopt the practices, although no adoption figures could be obtained. The pilot projects also demonstrated that land degradation and food insecurity can be reduced and livelihoods improved. Now needed are concerted efforts from government and donors to invest in conservation agriculture and to scale up dissemination of strategies whose success has been well shown through the pilot projects.

1 History and background

Conservation agriculture is a term summarizing a farming concept that embraces three basic principles: 1) reduced or minimal moving of the soil (reduced or no-tillage practices); 2) permanent soil cover (either with dead mulch or with cover crops); 3) useful crop rotations or associations that are in line with local preferences and circumstances.

History of conservation agriculture in Uganda

In Uganda both government and non-government organizations have initiated programmes and projects geared towards promoting elements of conservation agriculture. These technology-driven projects have focused on individual principles of conservation agriculture, and not all three concepts together. The projects have promoted the use of cover crops, soil and water conservation structures for erosion management, reduced or no tillage using animal draught power, etc. Though these technologies and projects have had pockets of success, problems of land degradation have continued and adoption has been limited to farmers participating in the projects. Figure 1 summarizes some of the projects with elements of conservation agriculture in Uganda using the farmer field schools approach.

The farmer field school (FFS) model is a farmer training approach, which is based on principles of adult education. It is based on an innovative, participatory, learning by discovery approach, which enables farmers to acquire an understanding of principles of Integrated Production and Pest Management (IPPM) that can be applied in any situation. Farmers learn how to analyse pest and disease problems in the field and how to make sound management decisions from both ecological and economic viewpoints. A farmer field school is a forum where farmers and trainers debate observations, apply their previous experiences and present new information from outside the community. The results of the meetings are management decisions on what action to take. Thus FFS as an extension methodology is a dynamic process that is practised and controlled by the farmers to transform their observations to create a more scientific understanding of the crop and livestock agro-ecosystem.

After an initial pan-African workshop on conservation tillage held in Harare, Zimbabwe, in June 1998, the Ministry of Agriculture Animal Industries and Fisheries (MAAIF) and the National Agricultural Research Organization (NARO) became increasingly aware of the considerable potential for conservation agriculture in Uganda. This was further affirmed through a World Bank-led study tour on conservation tillage in Brazil (November 2001), attended by a high-level Ugandan delegation, alongside other country delegations and partners such as FAO and RELMA—the Regional Land Management Unit (now in ICRAF, the World Agroforestry Centre). As a follow-up to the study tour, the Uganda delegation composed of senior government officials and technical specialists in the Soil Management Task Force proposed a number of actions to pilot and develop conservation agriculture. It sought FAO's technical support of the initiative, particularly to strengthen farmer-driven approaches to participatory technology development in conservation agriculture and land management and to assess implications.

1

Project name:	Uganda Land Management Project (ULAMP)
Project sites:	1 Mbarara District (subcounties: Kashongi, Kikagati, Rugaaga, Mwizi, Bugama, Nakayoyo, Bukiro, Kikyenkye, Bisheshe, Rikiri, Buremba) 2 Kabarole District (subcounty: Ruteete) 3 Arua District (subcounty: Pajulu) 4 Kapchorwa District (subcounties: Tegeres and Kaptanya)
Implementing agencies:	<ul style="list-style-type: none">Regional Land Management Unit (RELMA)Ministry of Agriculture, Animal Industry and Fisheries (MAAIF)District local governments
Number of FFS established:	1187
Number of FFS facilitators:	882
Donor:	Swedish International Development Cooperation Agency (Sida)
Project funding (USD):	1,750,000
Period:	July 1999–October 2003

3

Project name:	Management and Livelihoods for Smallholder Farmers (TCP/UGA/2903 (T))
Project sites:	1 Mbale District (subcounties: Busano and Busia) 2 Pallisa District (subcounties: Budaka and Petete)
Implementing agencies:	<ul style="list-style-type: none">National Agricultural Research Organisation (NARO)Africa 2000 Network Uganda (A2N)District local governments
Number of FFS established:	48
Number of FFS facilitators:	88
Donor:	Food and Agriculture Organization
Project funding (USD):	371,000
Period:	July 2002–December 2005

2

Project name:	Integrated Nutrient Management to Attain Sustainable Productivity Increases in East African Farming Systems (INMASP)
Project sites:	1 Wakisho District (subcounty: Wakisho) 2 Pallisa District(subcounty: Agule and Pallisa)
Implementing agencies:	<ul style="list-style-type: none">Environmental Alert (EA)Makerere University, Soil Science DepartmentDistrict local governments
Number of FFS established:	6
Number of FFS facilitators:	16
Donor:	European Union
Project funding (USD):	169,319
Period:	March 2002–April 2006

4

Project name:	Integrated Soil Productivity Initiative through Research and Education (INSPIRE)
Project sites:	1 Tororo District (subcounties: Osukuru, Kisoko, Kwape, Molo, Nagongera, Mella, Petta) 2 Busia District (subcounties: Busitema, Dabani, Masaba, Lunyo, Buhehe, Buteba)
Implementing agencies:	<ul style="list-style-type: none">Africa 2000 Network Uganda (A2N)CIAT/TSBFNational Agricultural Research Organisation (NARO)Makerere University, Soil Science DepartmentDistrict local governments
Number of FFS established:	48
Number of FFS facilitators:	62
Donor:	Rockefeller Foundation
Project Funding (USD):	221,450
Period:	May 2002–June 2005

In 2002, the government of Uganda sought technical and financial assistance from FAO to implement a conservation agriculture pilot project, which aimed at introducing the three principles through an approach using farmer field schools as an integral part of improving land management and livelihood strategies of smallholder farmers. This was the first such project in the country that focused on demonstrating the applicability of conservation agriculture systems in Uganda and its multiple benefits in terms of productivity (saved labour, enhanced income, products diversified), sustainable use of natural resources (biodiversity and resilient land-use systems) and environmental services (better water quality, reduced erosion).

The pilot project areas

This case study presents experiences and lessons learned from two pilot conservation agriculture projects implemented in three districts of Pallisa and Mbale in eastern Uganda, and Mbarara in south-western Uganda (see colour section). Conservation agriculture was introduced in Bisheshe Subcounty, Ibanda District (formerly part of Mbarara District) in 2000 through a Sida-funded project, Uganda Land Management Project (ULAMP), and in eastern Uganda in 2002 through a pilot FAO Technical Cooperation Project (TCP/UGA/2903). In Mbale and Pallisa Districts, activities were piloted in four contrasting microcatchments that represent areas undergoing accelerated land degradation in selected parishes, two in Mbale (Busano and Busiu) and two in Pallisa (Budaka and Petete).

Project activities with farmers were, to the extent possible, concentrated within the selected catchments to facilitate monitoring and observation of aggregate benefits of better land management in terms of hydrological regime, water quality and erosion control. This is possible by eliminating or reducing tilling in preparing the land and by introducing efficient technologies for managing weeds and saving fuelwood. According to the 2002 population census Mbale District has a population density of 487 persons/km², Pallisa 229 and Mbarara 410. Most are smallholder farming families.

Mbale and Mbarara Districts are medium-altitude zones lying between 1200 and 2100 m, although Mbale, lying in the foothills of Mount Elgon, has high altitude and steep land. Pallisa is a lowland area lying between 1000 and 1200 m with a gently rolling landscape and wide valleys draining into Lake Kyoga. The soils in Pallisa are generally sandy loams, low in soil organic matter and fertility, and often acidic. In Mbale crops grown on the steep, highly dissected slopes include perennials like banana and coffee and annuals like maize, beans, irish potato and vegetables. Mbarara is in a coffee–banana–livestock agricultural zone. The major crops grown are banana, coffee (arabica), maize, beans, groundnut, millet and sweet potato. Others crops, grown mainly on a small scale, are cassava, irish potato, field pea and yam, mainly as reserve food. Exotic and local vegetables are grown on a small scale, mainly as a backyard activity by women. A limited number of livestock, mainly cattle, goats, pigs and chicken are kept. Most of the cattle are the local long-horn Ankole breed, but with introduction of zero-grazing units, a large number of farmers have started keeping upgraded crosses of cattle. Local goats are also being upgraded with pure breeds of exotic species. In Pallisa District, the major crops grown include cassava, sweet potato, sorghum, rice, cowpea and groundnut.

Threats to agricultural productivity and rural livelihoods in Mbale and Mbarara include loss of soil through erosion and landslides, intensified by loss of vegetative cover on the steep slopes through agriculture and deforestation. The soils in Mbale have a moderate-to-high clay content and are productive if well managed; those of Mbarara are predominantly sandy loams prone to severe degradation due to soil erosion triggered by deforestation of the hills, overgrazing and poor land-cultivation practices. The range of soils is shallow and sandy mixed with gravel on the hilltops, predominantly sandy loams on the gentle slopes, and fairly deep silty-loams in the valleys. In some parts of Bisheshe, underlying layers of limestone make the soils unstable and prone to severe soil erosion.

Due to the hilly topography and high population density in both Mbale and Mbarara, the land holdings per household are small, ranging from 0.25 to 1 ha. Land fragmentation in all sites is a common practice, and the land shortage means that the existing arable land is intensively cultivated. Most of the arable land is located on the foothills, three-quarters of which is under banana and coffee. The degraded hillsides are being increasingly cultivated to produce annual crops such as millet, maize, beans and sweet potato. Cattle are mainly grazed communally on the hilltops during the rainy season and in valleys during the dry season.

Average annual rainfall in Mbale is over 1500 mm and in Mbarara over 1300 mm; Pallisa receives about 1000 mm per year (figs. 2, 3). All sites have a bimodal rainfall pattern: the first rains are from mid-February to the end of May and the second rains from August to the end of December. The rainfall season averages 100 rain days for both. Most of the rainfall in Mbarara is experienced during the second rain season, from August to December. The intense downpours during this period cause heavy runoff that triggers severe soil erosion, soil capping, and occasionally landslides. High population pressure has led to encroachment into marginal lands and wetlands. Rice growing in the wetlands has increased tremendously from 300 ha to 5000 ha in these areas in the last 30 years. Due to land degradation in the upper zones, rivers and streams are heavily silted and the zone experiences frequent flooding.

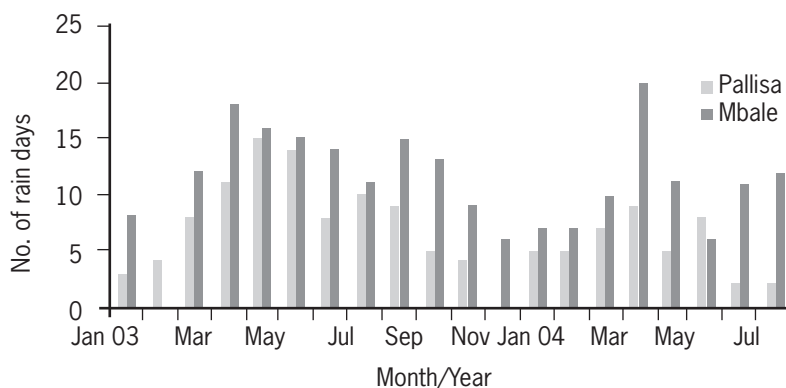


Figure 2. Number of rain days per month in Pallisa and Mbale catchments.

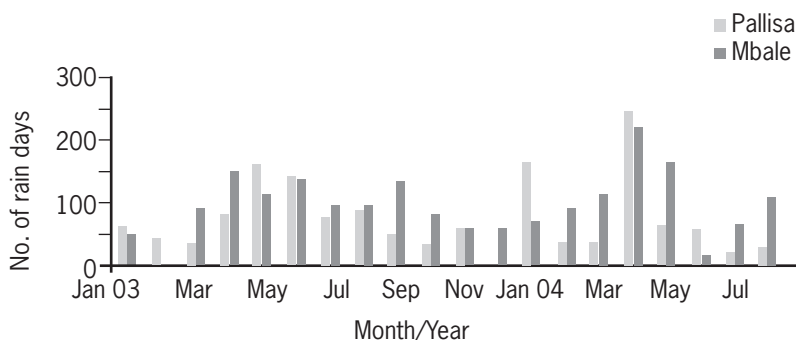


Figure 3. Total monthly rainfall in Pallisa and Mbale catchments recorded over 18 months by farmer field school groups.

2 Type of conservation agriculture practices

Once they realized they needed to reverse land degradation, farmers in the project sites have employed improved land-management practices such as establishing soil and water conservation structures (*fanya juu* and *fanya chin*), using cover crops in improved fallows, and rotating crops in various combinations. Despite these efforts, there have been serious shortfalls in individual practices in addressing loss of soil fertility and land degradation, resulting in adverse effects on crop and livestock productivity and on the environment.

To address these shortfalls, conservation agriculture was introduced as an alternative land-management practice. The concept emphasized the use of site-specific combinations of practices aimed at:

- checking and minimizing soil erosion mainly through reduced or no-tillage practices
- building soil organic matter content by not burning crop residue, thus improving the chemical and physical properties of the soil
- controlling weeds
- increasing soil cover to protect soil from the negative effects of rainfall energy and solar radiation, and to improve the water infiltration rate and conserve soil moisture during dry spells

The entry point of conservation agriculture in these microcatchments varied greatly depending on site- or situation-specific constraints in a given catchment or household. Some considerations when promoting conservation agriculture included differences in wealth status or resource endowment (rich, poor or medium), availability of household labour, and crop and or livestock farming system. Conservation agriculture practices were promoted as a package and not as individual practices as known by many farmers. Several combinations of practices were demonstrated and tested on fields depending on the field operation being carried out and cropping system in use as shown below.

Land preparation

Land is prepared principally to rid the fields of weeds and to make a fine seedbed for planting annual crops. Instead of using a traditional hand hoe, weeds were sprayed with herbicide, slashed or smothered with legume cover crops like *Mucuna*, which were also either sprayed with herbicide or slashed before the plot was planted (colour section).

Planting

Different **planting tools** are used to reduce tillage, soil compaction from traffic and the amount of labour required during planting. Tools include the planting stick (colour section), the ox-drawn ripper planter, the jab planter, and a hand hoe.

The **permanent oblong hole method** was demonstrated for producing maize; it is similar to the *zai* method used in Zambia (FAO 2005). The planting pits (colour section) are dug (approximately 35 cm long, 15 cm wide and 15 cm deep), spaced at intervals of 70 to 90 cm. Each hole is filled with 1–2 kg of compost manure, which is mixed with topsoil and planted with nine seeds of maize per hole, thus giving an optimum seed rate of 25 kg/ha of maize (Longe 5 maize variety).

Weed control

Weed control constitutes planting cover crops in banana, coffee and vanilla (colour section) plantations in combination with soil and water conservation structures, mulching and applying manure. The study team evaluated several cover crops including *Mucuna pruriens*, *Dolichos lablab*, *Canavalia ensiformis*, *Phaseolus vulgaris* (bush bean), pumpkin and yellow passion fruit.

In **soil and water management**, water-harvesting pits are constructed in trenches aligned on contours in which new banana stools are planted (colour section). The raised bands are mulched and planted with cover crops.

Soil fertility improvement

To improve soil fertility, permanent narrow-based terraces are dug on which vegetables are planted after compost manure and mulch have been applied (colour section). Cover crops are later planted to cover the surface of the terraces after the vegetables are harvested.

Crop rotations and associations. A participatory diagnosis of constraints and opportunities with regard to crop rotations and associations was carried out in two different cropping systems: banana–coffee for Mbale and cotton–cereal in Pallisa Districts (FFS AESA reports 2003). This revealed that:

- Most farmers did not rotate crops or rotated inappropriately, especially with their annual crop. For example, farmers planted maize in the first season (March to June) and in the following season (July to December) planted cotton, which has similar crop pests and diseases. Farmers and extension officers attributed this neglect of alternative potential crops in the rotations to a number of reasons:

- traditional attachment to certain crops like beans
- food security
- risk aversion
- land shortage
- suitable soils for certain crops
- lack of alternative crop seed
- market and income forces
- ignorance of the need for improved rotations and the benefits and opportunities they afford
- In some cases farmers practised rotations that were appropriate but so short that they did not break pest and disease cycles, or improve soil fertility such as was the case of rotation of groundnuts with finger millet or sorghum.

The farmer field schools learned the importance of choosing appropriate crop combinations and associations to avoid possible competition between different plant species. For example, through their study plots, farmers in Petete and Sapiri microcatchments learned that mucuna and lablab are not suitable for intercropping with cotton, whereas pigeon pea (*Cajanus cajan*) and canavalia (*Canavalia ensiformis*) make beneficial associations. Farmers also found that appropriate crop rotations and combinations were important in managing weeds. Crop combinations and rotation with habits that are morphologically different (variable plant size and form) and physiologically different (variable response to factors such as nutrient and moisture stress) were seen to suppress weeds and to break pest and disease cycles. Optimal plant spacing of different crop associations and combinations minimized the opportunity for weeds to establish and suppressed weed growth.

Farmers greatly preferred cover crops with multiple uses such as for food and fodder and disliked those that had pest problems such as *Crotalaria grahamiana*.

3 Effects, benefits and results of conservation agriculture practices

Farmer field school experimentation with conservation agriculture

Through the conservation agriculture study and experiment plots in farmer field schools farmers were exposed to a variety of options for land preparation that could reduce demand for labour in preparing land and weeding—the most time-consuming tasks for households. Before farmer field schools introduced conservation agriculture, farmers knew only one way to prepare land and weed which involved much moving of soil (tillage) using either the hand hoe or the ox plough. During farmer field school studies, farmers evaluated several options that would minimize soil disturbance and at the same time reduce the demand on the household for labour. These options or practices included using herbicides, slashing, and managing cover crops. The practices were evaluated in terms of labour requirements, productivity (crop yield), weed prevalence and overall economic assessment.

Labour requirement for field operations for maize

Given the low and erratic rainfall in the study areas, timeliness of field operations is critical to achieve a good crop yield. But good timeliness is made difficult by labour bottlenecks. HIV, AIDS and malaria are causing and by rural–urban migration, especially of the youth. An assessment of timeliness and labour requirement to prepare a hectare of land for maize was carried out. Eight farmer field schools compared conventional use of a hand hoe or an ox plough with conservation agriculture practices. Evaluation showed that options involving cover crop management required four times less labour than the other options—herbicides and weed slashing on their own, or conventional ploughing and hoeing of weeds (table 1). Because farmers perceive herbicides to be expensive and not readily available, they found managing cover crops by slashing the most feasible option.

Farmers learned that the cheapest options (that is, of those within their resources) were slashing and using cover crops, as shown in table 2. From the knowledge and skills obtained in these farmer field schools, 60% of the members subsequently adopted slashing and using cover crops. The *Mucuna* cover crop used was particularly appreciated for suppressing weeds effectively.

Weeding labour and associated costs

Weeding absorbs over 50% of smallholder farmers' production costs. It also occurs at times when the demand for labour is quite high and needed for many farm activities. Farmers found that adopting conservation agriculture practices greatly reduces the labour they need for weeding. Options that used and managed cover crops, either by slashing or by using herbicides, required less labour and were therefore more cost effective than other practices (table 3).

Table 1. Labour requirements for land preparation (workdays per hectare)

Activity, operation	Conventional		Herbicide use		Slashing		Cover crop + slashing		Cover crop, no herbicide	
	Work- days ^a	Oxen days ^b	Work- days	Oxen days	Work- days	Oxen days	Work- days	Oxen days	Work- days	Oxen days
Time spent clearing bush	17.5	5	17.5	5	17.5	5	0	0	0	0
Time spent on 1st ploughing	37.5	2	0.0	0	0	0	0	0	0	0
Time spent on 2nd ploughing	18.7	1	0.0	0	0	0	0	0	0	0
Time spent spraying herbicide	0.0	0	5.0	5	0	0	0	0	5	5
Time spent slashing weeds/cover crop	0.0	0	0.0	0	5	5	5	5	0	0
Total	73.7	8	22.5	10	22.5	10	5	5	5	5

Source: FFS – AESA reports 2003

^a 1 workday = 4 hours of effective working, ^b 1 oxen-day = 6 hours of effective working

Table 2. Land preparation costs per hectare of maize (USD)

Activity/operation	Conventional	Herbicide use	Slashing	Cover crop + slashing	Cover crop + herbicide
Bush clearing	20.8	20.8	20.8	20.8	20.8
Cost of 1st ploughing	20.8	0.0		0.0	0.0
Cost of 2nd ploughing	20.8	0.0		0.0	0.0
Inputs					
Cost of herbicides (Round-Up max)	0.0	27.8	0.0	0.0	50.0
Cost of herbicides (Laso, atrazine)	0.0	25.3	0.0	0.0	0.0
Cost of hiring a sprayer	0.0	1.4	0.0	0.0	1.4
Cost of labour for spraying	0.0	3.9	0.0	0.0	3.9
Total	62.4	79.2	20.8	20.8	76.1

Source: FFS – AESA reports 2003/2004

Table 3. Labour requirements (workdays) and cost (USD) for weeding 1 ha of maize

Weeding	Conventional		Slashing		Cover crop + slash		Cover crop + herbicide	
	Labour	Cost	Labour	Cost	Labour	Cost	Labour	Cost
1st	17.5	20.8	17.5	20.8	9	7	9	10
2nd	17.5	20.8	17.5	20.8	0	0	0	0
3rd	0.0	0.0	17.5	13.8	0	0	0	0
Total	35.0	41.6	52.5	55.4	9	7	9	10

Source: FFS – AESA reports 2003/2004

Herbicides were not used alone; 1 workday = 4 hours of effective working

Using cover crops gave higher yields (table 4) because they provided more fertility by fixing nitrogen and restoring organic matter (root and leaf litter), and they suppressed the weeds. The data presented were collected by farmers with the guidance of facilitators from farmer field schools, but no scientific statistical analysis was carried out (Sapiri and Petete FFS end of season AESA report, 2003).

Table 4. Maize yield with different land preparation treatments in farmer field school plots

Land preparation (treatment)	Grain yield (kg/ha)
Conventional	2458.6
Herbicide use	2618.6
Slashing	2453.8
Cover crop + slashing	3126.0
Cover crop + herbicide	3008.0

Source: FFS AESA reports 2003/2004

Farmer monitoring and evaluation

Mr Kasimire of Bisheshe, Mbarara District, is one of the farmers who monitored physical and agronomic changes on his farm—plant growth and vigour, occurrence of pests and diseases, weed prevalence, soil conditions and yields. Table 5 gives Mr Kasimire’s results when using or not using conservation agriculture practices.

4 Adaptation and adoption

The farmer field school approach was chosen as an alternative to the traditional extension approach in which farmers are passive recipients of externally formulated extension messages. This approach involves discovery-based learning, with extension agents acting as facilitators to support the learning as well as the adoption of new technologies that the farmers themselves test directly. It was adapted to promote conservation agriculture by developing a curriculum that addresses it and other livelihood-related issues.

As part of the learning process in farmer field schools, farmers’ groups were helped to establish study plots or experiments in their own fields to test the conservation agriculture practices and principles through discovery-based learning by doing. The simple studies and experiments centred on the three principles of conservation agriculture: 1) permanent soil cover through cover crops or mulch, 2) no or minimum tillage with direct seeding, and 3) improved crop rotation. The studies were carried out for three seasons in 16 farmer field schools, each ‘school’ representing a replicate of the experiment, using maize (variety Longe 5H) as a test crop. Data were collected using a farmer field school monitoring tool—Agro-EcoSystem Analysis (AESAs)—weekly or fortnightly depending on the nature of the data, and compiled into AESA reports. Generating AESA reports involves field observation by members of the farmer field schools, recording key field observations in sub-groups, discussing observations in plenary, and drawing relationships, action points and conclusions from the observations.

The farmer field schools assessed the following aspects, through monitoring and evaluating studies for one season:

- agronomic crop performance—percentage of crops that germinated, crop vigour, weed profiles, grain and stover yields
- economics—labour efficiency; cost of inputs and outputs per treatment
- farmers’ qualitative assessments

In each microcatchment the schools were coordinated by an elected network whose role included mobilizing farmers towards field school activities, networking and sharing information, resolving conflict among members within groups, managing a revolving fund, and influencing local policy and advocacy (table 6).

Farmers acquired knowledge and skills through experiential learning that enabled them to adapt conservation agriculture on their farms; this was observed among innovative farmers particularly. Some of these farmers applied this knowledge to diversify their agricultural activities by setting up high-value enterprises such as pineapple, vanilla and banana plantations. Improved soil fertility and improved moisture management led to improved production that eventually resulted in a good

Table 5. Field observations of practices on maize and beans, as reported by Mr Kasimire after four cycles (seasons) in 2002

Factor	Conservation agriculture plots	Control plots (non-conservation agriculture)
Plant health and growth	<p>Maize and beans crops grew with vigour.</p> <p>Each plant of maize produced 2 cobs. On average, beans (K132 variety) produced 35 pods per plant</p>	<p>The maize crop remained weak and was stunted. Some plants failed to produce cobs. The bean crop showed some vigour but the number of pods, an average of 10 pods on each plant, was far less than those in conservation agriculture plots of the same variety.</p>
Pests and diseases	<p>At the seedling stage cutworms (<i>Phyllophaga spp</i>) destroyed some plants. They were replaced at the start of the rains and the damage ceased. Maize streak disease was widespread and caused severe crop damage</p>	<p>There was no pest invasion at seedling stage.</p> <p>Maize streak was observed on many plants.</p>
Weeding	<p>No serious invasion of weeds except wandering Jew (<i>Commelina benghalensis</i>), which was removed during weeding from the planting sites</p>	<p>Many weed species; needed intensive weeding twice during the growing period.</p>
Soil conditions	<p>Soils remained moist and soft even during dry spells. Accumulation of organic matter and litter on the topsoil led to the presence of earthworms. Topsoil particles had a smooth feel; sticky on rubbing (indicating moisture)</p>	<p>Maize plots affected by soil erosion because the land remained bare. After the rains, the soil dried quickly and the topsoil particles remained separate (loose, dry and prone to erosion).</p>
Yield		
Maize	<p>Farmer got 3800 cobs or 28 basins of dried maize seeds equivalent to 452 kg or 4.5 100-kg sacks</p>	<p>2625 cobs from which the farmer got 13 basins of dried maize seeds, equivalent to 260 kg or 2.5 100-kg sacks</p>
Beans	<p>Farmer got 105 kg (1 sack) of beans</p>	<p>Farmer got 97 kg (1 sack) of beans</p>
Selling price of maize per kg = USD 0.14		
Selling price of beans per kg = USD 0.22		
Income	<p>Maize: 452 kg x USD 0.14 = USD 62.7</p> <p>Beans: 105 kg x USD 0.22 = USD 23.1</p>	<p>Maize: 260 kg x USD 0.14 = USD 36.4</p> <p>Beans: 97 kg x USD 0.22 = USD 21.6</p>

Table 6. Typical conservation agriculture curriculum for a farmer field school

Phase	Weeks (no.)	Learning themes
Pre-experiment phase (preferably before the season starts)	11	Concepts and principles of farmer field schools
Experimental phase	20	Experimenting with technology, agroecosystem analysis
Post-experiment	9	Graduation, second-order generation schools, linked to other development initiatives

See details in appendix 1

crop harvest and hence improved food security. In the long run, farmers feel that food will be more available for a range of household types that will have a positive impact on the household nutritional status. Boxes 1, 2 and 3 give testimonies of farmers' experience with conservation agriculture under different situations.

5 Key challenges and lessons

Providing and managing a permanent soil cover

In the conservation agriculture study plots, field school farmers experimenting with cover crops learned that they have both positive and negative effects. The choice of what cover crop to use depends on the site-specific needs to be addressed. Table 7 gives farmer assessment of cover crops tried in the Mbale and Pallisa field schools. Earlier studies by Nyende and Delve (2002) in Tororo District, close to Pallisa and Mbale Districts, had indicated that farmers' preference for cover crops is quite site specific.

Equipment trials conducted by the Agricultural Engineering and Appropriate Technology Research Institute (AEATRI) within farmer field schools show that to effectively manage cover crops using the mechanical animal-drawn knife-roller, the cover crop should be at its final vegetative cycle stage. For legumes this is between full flowering and formation of the first pods; for grass species it is during the milky stage; and for other species like oil radish, between flowering and maturation of seeds. If a mixture of cover crops is used, it is important to choose species with a more-or-less uniform growing cycle. Under Ugandan conditions, however, as farm size is small and may not allow legume and grass rotations as, for example, in Brazil, the knife-roller will also be used to knock down, flatten and score cereal crop straws (maize, sorghum, finger or pearl millet) and other agricultural residue ready for direct planting through the vegetative mulch.

Local evaluation of alternative cover crops and dead mulches showed:

- Appropriate and sufficient biomass for mulching was in short supply and regulatory bylaws on wild fires were lacking. Widespread burning destroys available material that could be used for mulch. Farmers also fear burning of their mulched gardens.
- Predators like rats and pests such as cutworms destroyed the early germinated plants under mulched fields, causing loss and uneven growth.

Box 1. Mr Kasimire tells what conservation agriculture means for his livelihood

Kaanama common interest group in Bisheshe, Mbarara District, received demonstrations on conservation agriculture. Mr Kasimire is an active member. He lives on sloping land whose soils are gravelly and barren. As these gravelly soils do not hold water long, growing crops was difficult. Mr Kasimire was frustrated with his barren land and wanted to sell it but he neither found a buyer nor had enough money to buy an alternative plot. He failed to provide for the family. He could not pay school fees for his children. Finally quarrels with his wife became frequent. Mrs Kasimire had to spend most of her time working at other people's farms for food and money. She was jealous of women in the village who had better land and could grow and sell good crops. The Kasimire children also suffered. They not only failed to get school fees but were also poorly fed and suffered from malnutrition. As a coping mechanism, some of the children were sent away to live with relatives, simply to get enough to eat.

Learning about conservation agriculture through the Kaanama common interest group transformed Kasimire's life, shaped his destiny, and helped others too. Using permanent planting stations and *Mucuna* cover crop, Kasimire planted maize (Longe 5 variety) on the most degraded piece of land, a plot about 50 m². From it alone he harvested 100 kg. In the second season he planted beans (K132) on the same piece of land and harvested 60 kg. During the third season he planted about half a hectare of maize and harvested 4 bags estimated to weigh 450 kg. The fourth season saw him planting climbing beans; from one plastic cup of climbing beans he got 100 kg. Mr Kasimire kept record of his production in an exercise book.

Using the same conservation agriculture principles he planted onions on another plot. He harvested 14 basins from two plots each measuring 1.5 m x 8 m, out of which he sold 12 basins for the equivalent of USD 66.70. In the following season he planted tomatoes on the same piece of land. He harvested 97 basins and sold each for USD 1.70, earning USD 161.70 in total. Before the season ended he planted cabbage seedlings and sold 140 heads, in addition to what the family consumed. On the other half of the plot, he planted carrots and sold them for USD 7.80. In the third season, he planted 9 lines of onions and harvested 40 basins. In all he earned USD 149.30.

Since this experience with conservation farming, Kasimire has abandoned his plan to sell his land or migrate. During the three years he has practised conservation agriculture he has been able to pay school fees of up to USD 111 a term and purchase materials for his one child in secondary school and four in primary school, mainly by selling crop produce. In addition, he has renovated his house.

Mr Kasimire has now bought more land that includes banana and coffee. He has also bought a cow for USH. 140,000 from sales of honey. He has bought household utensils and other equipment. He is now a member of a credit and savings group and is up to date with his subscription.

Mr Kasimire has noted changes. The soils are darker coloured, stones in the fields are covered, and the layer of topsoil is thicker. Soil erosion is controlled. He has also noticed changes in the family—family income has improved and there are no more quarrels with his wife. They need less labour and the children willingly participate in the family chores. They no longer throw away household waste as they compost it. The cropped area on the farm is less yet productivity has increased. He has adopted goat rearing and bee-keeping. The animals provide manure and the bees pollinate his crops.

Conservation agriculture in Bisheshe started with 10–14 people and has now been taken up by over 80 farmers.

Source: Anthony Nyakuni, ULAMP Project Manager

Box 2. What conservation agriculture means to Emmanuel Mukari and fellow villagers

The Nabikyenga Farmer Field School is one of 16 farmer field schools initiated under the FAO-funded conservation agriculture project in Nabikyenga village, located 400 km from Kampala. The village is in Busano Parish, Busano Subcounty, Mbale District. Rainfall is bimodal with the first rains occurring from March to July, and the second rains from September to November. The area is characterized by steep slopes—60° or even more. Farmers in congested households whose average family size is 10 persons cultivate small tracts of land from as small as 100 m² to half a hectare. Main crops are banana, field peas, beans, onion, cabbage, carrot, irish potato and coffee.

Emmanuel Mukari is a member of the Nabikyenga Farmer Field School. With a family of eight children (six boys and two girls) deriving a livelihood from half a hectare of land, he is considered one of the richest people in the village. Meeting the needs of his family such as health and education is a big concern for him. He knows very well that this half hectare cannot support his children, and into the future, their children.

Fortunately, the conservation agriculture approach to land management has given him some hope. The learning by discovery that occurs in the field school, using the agroecosystem analysis (AESA) tool, with guidance from the school facilitator, has had a miraculous effect. 'I volunteered to give my land as a study plot for our field school,' Mr Mukari says. 'We then recorded the problems on the 100-m² plot of coffee, which included low soil fertility, extreme erosion and poor agronomic practices. In the study plot I implemented a number of practices the group agreed on: harvesting water, stabilizing soil with grass bunds, and mulching that. After two seasons of practising conservation agriculture, we recorded our observations using AESA. My plantation now looks better. I used to get 1 bag (70 kg) of coffee but now I get 2 bags (140 kg). The size of the coffee berries has increased and now I get 1 kg of processed coffee from 2 kg of raw coffee, implying that I now get more processed coffee from my raw coffee. So I never intend to sell raw coffee again at USH 500 per kilogram (and get only USH 2000 from 4 kg). Instead, I will process my 4 kg of raw coffee, get 2 kg of processed coffee, sell it at USH 2000 per kg and get USH 4000. My revenue from my coffee has doubled. All we need now is a coffee-processing machine for the group to cater for the increased demand of its services.'

Conservation agriculture practices have spread through the whole village like a bush fire and to-date over 80% of the members in the four schools and about 50% of non-members in the microcatchment have adopted conservation agriculture practices, mainly harvesting water using trenches (*fanya juu* and *chini*), stabilizing trenches using grass bunds and tree shrubs, capturing rainwater runoff from roads and courtyards, and mulching with both live and dead mulches. 'Farmers on this footslope have now become serious about practising conservation agriculture. They are now forming groups and consulting us to advise them on what to do,' says Mukari.

Mukari has a daughter at Makerere University whose fees he is paying privately. He says she has drained his small resources to the extent that he is not able to pay to educate his other children. He however hopes and believes that from the results he has seen so far, his worries will be no more and all his children will be able to attend school.

Source: John Peter Opio, Agricultural Training Expert (TCP/UGA/2903 Project)

Box 3. Sapiri assesses conservation agriculture in their microcatchment

The Sapiri community (in Budaka Subcounty, Pallisa District) and its local leaders perceived poor roads as one of the priority problems in the area. Farmers got a raw deal whenever they wanted to market their produce because buyers could not reach them due to the poor road infrastructure. According to Mr Shiny, the Budaka chief, the subcounty allocated more than 40% of the budget to road maintenance. The road would require repairs and maintenance twice every year. Mr Shiny noted that it cost USH 4 million every year to repair and maintain a 10-km road that passes through Sapiri Parish. The major cause of road destruction has been rainwater runoff.

When several farmers adopted conservation agriculture, however, the Sapiri microcatchment showed significant change in just two years. The adopted conservation agriculture practices, which they initially thought would only improve water harvesting for crop use, also provided significant positive benefits for road maintenance. Initially, only members of the farmer field school adopted the recommended practices for conserving soil and water in the microcatchment. But later non-members too adopted them, when they saw how the farmers who had adopted earlier had benefitted. Practices include *fanya juu* and *fanya chini*, water diversion channels to direct runoff away from roads, grass bunds, and water basins locally known as *bafus*. Farmers who own land along roadsides also learned to divert water from the road to their crop fields, a practice they copied from road maintenance workers.

Within two and a half years, local leaders together with the entire community noted that gullies and potholes, water ponding in low-lying areas and impassable bridges in the road caused by running water have all been greatly reducing, simply by managing rainwater runoff on the roads.

Mr Shiny says that the road-maintenance budget the subcounty allocates to Sapiri Parish has been slashed to half, because the roads are now repaired and maintained only once instead of twice in a year as formerly. Farmers are directly benefiting from water diverted from roads and from their compounds into their crop fields. 'We have recommended to the subcounty council that a bylaw be passed by the council for community members to adopt conservation agriculture practices that prevent destruction of roads. We would rather spend money to support farmers on such conservation agriculture practices than hire or buy expensive equipment for road construction and maintenance,' says Mr Shiny.

Source: Paul Nyende, Land Management Expert, (TCP/UGA/2903 Project)

- Due to shortage of land, grazing animals often invade cover crops in conservation agriculture plots, especially during the dry periods. There is a need to introduce and ensure sustained control of livestock.

For wider adoption of cut-and-carry mulch, farmers' fields must be located near land that will produce mulch material, that is, fallow land, low-lying grazing lands, road margins or poor uncultivated lands. Livestock grazing and burning across the community's territory must be controlled. Rats should be controlled by using bait or encouraging birds of prey. Damage by pests such as cutworms is expected to diminish with improved soil health and crop rotation.

Tools and equipment

Animal-drawn knife-roller

The AEATRI model of a knife-roller consists of a metallic frame with a cylinder made from 4-mm steel sheet with up to 10 sets of cutting knives attached to the axle. The cylinder has an opening with a plug; it is filled with either water (up to 100 litres) or dry sand (up to 160 kg) to increase its weight, but the weight must be matched to the size and capacity of the animals being used.

To date, four units each of knife-roller models with cylinder diameters of 0.30, 0.35 and 0.40 m and a working width of 1.20 m have been made and are being tested with farmers. A typical unit has a working weight of 200–220 kg when empty, and a maximum weight of 380 kg when fully loaded with sand. The weight is adapted to East African zebu oxen, which weigh on average 200–250 kg. In contrast, the Brazilian knife-roller model weighs over 1000 kg and is suited to their heavier draught animals, which may weigh between 800 and 1000 kg (Odogola et al. 2004). An example of the AEATRI knife-rollers is shown in the coloured section.

Adaptation and field testing of the animal-drawn knife-roller reveals the following factors that limit its use and performance:

- *Non-uniformity in establishing cover crops.* In areas where cover crops were not uniformly established, the knife-roller did not effectively flatten them, especially canavalia.
- *Wet soils.* In areas where soils were extremely wet, the knife-roller simply bent the cover crops but did not break up the stalks sufficiently to let them desiccate rapidly. The knife-roller should be used when soils are relatively dry, for example, before the onset of rains.
- *Uneven ground surface.* In areas where the ground surface was uneven and irregular, the knife-roller simply rolled over the cover crops without breaking up the stalks as required. To effectively manage weeds and cover crops, the ground surface should be relatively flat.
- *Untrained oxen and ox drivers.* To effectively use the knife-roller to mechanically manage cover crops, both the draught animals and their handlers must be adequately trained and given enough practice. The weight of the knife-roller should be matched to the capacity of the animals used and to the type of cover crop being handled.

Jab planter

Two types of hand-operated jab planters (one for dropping seed only and the other for dropping seed and fertilizer), known as *matracas* in Brazil, were imported and tested with maize and beans at all farmer field schools in the two districts. At all sites, farmers preferred the jab planter that delivers seed and fertilizer because it reduces the number of field activities and helps make operations timely. To plant in straight lines a string was used with internodes marked at appropriate intervals corresponding to the spacing recommended for the crop. The person using the jab planter walked along the string while carefully jabbing the soil at the marked intervals.

Table 7. Farmers' assessment of local cover crops and shrubs

Cover, shrub	Positive aspects	Negative aspects
<i>Mucuna pruriens</i>	<ul style="list-style-type: none"> • Improves soil fertility • Suppress weeds effectively • Produces plenty of biomass • Quick maturing 	<ul style="list-style-type: none"> • Not edible • Not good for intercropping (climbs the crops) • Requires much labour for clearing and incorporation • Can harbour snakes and wild cats if planted near the home
<i>Canavalia ensiformis</i>	<ul style="list-style-type: none"> • Improves soil fertility • Has fodder value • Suppresses weeds • Easy to multiply (heavy seed production) • Good for intercropping 	<ul style="list-style-type: none"> • Beans not edible
<i>Crotalaria paulina</i>	<ul style="list-style-type: none"> • Improves soil fertility • Suppresses weeds • Leaves used as a vegetable 	—
<i>Crotalaria grahamiana</i>	<ul style="list-style-type: none"> • Improves soil fertility • Suppresses weeds 	<ul style="list-style-type: none"> • Caterpillar pests
<i>Tephrosia vogellii</i>	<ul style="list-style-type: none"> • Improves soil fertility • Controls mole rat 	<ul style="list-style-type: none"> • Pests eat pods, leading to poor seed formation
<i>Dolichos lablab</i>	<ul style="list-style-type: none"> • Very good fodder • Edible by humans • Improves soil fertility • Suppresses weeds 	<ul style="list-style-type: none"> • Poor establishment
<i>Sesbania sesban</i>	<ul style="list-style-type: none"> • Excellent fodder • Improves soil fertility • Provides firewood • Suppresses weeds 	<ul style="list-style-type: none"> • Produces too many seeds; plant can become a weed
Pigeon pea	<ul style="list-style-type: none"> • Improves soil fertility • Has food and fodder value • Suppresses weeds • Easy to multiply (heavy seed production) • Good for intercropping 	—
Pumpkin	<ul style="list-style-type: none"> • Has food value • Suppresses weeds • Easy to multiply (heavy seed production) • Good for intercropping 	<ul style="list-style-type: none"> • Does not improve soil fertility

Source: Nyende and Delve 2002

The following limitations requiring further investigations were experienced with the Fitarelli hand jab planter:

- The fertilizer dropped at rate that was two times that recommended; the tool had no provision for adjustment. Feedback is required from manufacturers, either locally established or foreign suppliers, to provide for fertilizer adjustments in new jab-planter designs. Later models in Brazil have been fully adjusted for fertilizer monitoring.
- The wood used in making the jab-planter tool frame is weak and cannot sustain the force exerted when planting. This aspect also requires reinforcement.
- When soils are heavy clay or are wet, they tend to clog the jab planter, negatively affecting operations. Although attention must be paid to the soil moisture content, the jab planter may not be suitable for clay soils.
- The planter can be used effectively only with larger seeds such as maize, beans, soybean and groundnut and not with small seeds like millet and sorghum.
- On initial trials, the jab planter was tricky to operate. This aspect was solved through regular practice and training.

Despite these shortfalls with the jab planter, farmers appreciated its positive attributes:

- It reduces drudgery and only about a third of the time needed when using a stick for direct seeding. With the jab planter, only one person is required to make the hole and drop the seed and fertilizer.
- It can improve the timeliness of establishing a crop.
- Smallholder farmers can afford the tool.
- With relatively dry and light sandy loam soils, the jab planter can be very effect.

Calibration, repair and maintenance of conservation agriculture equipment

Equipment used in conservation agriculture such as pesticide and chemical applicators and direct planters must be calibrated if they are to operate at the required capacity and expectation. Although calibration procedures have been explained and demonstrated on farm, the procedures are complicated and present serious challenge to both farmers and facilitators. More training and demonstrations will be needed to counter this challenge

Local blacksmiths and artisans can easily repair and replace soil-acting parts such as planter shares and discs. These artisans (for example those at Kibuko village near Mbale) have generations of experience and are well known and respected in their localities. The facilities available are quite basic. Metal is heated on a charcoal-fired forge and temperatures are raised with hand-operated fans. The main demand is for repair of agricultural tools, animal-drawn implements and bicycle parts. Items repaired and replaced include hoes, axes, plough shares, landsides, plough handle supports, and sometimes mouldboards. Hand tools (hammers, files, hacksaws, spanners, drifts and punches) are used, but electricity is not available. Raw materials are in short supply and artisans must get their materials from Kampala, especially 3- and 4-mm mild steel sheets and carbon steel for parts exposed to abrasive soil conditions.

Acquiring and financing conservation agriculture equipment

NARO-AEATRI has been involved in developing prototypes and in testing and manufacturing new equipment such as hand hoes, animal-drawn implements and processing equipment. However, poor links with the market and high production costs pose a serious problem in stepping up to larger-scale production. Currently production and supply in the private sector is limited to Soroti Agricultural Implements and Machinery Manufacturing Co (SAIMMCO) in Soroti District and Agricultural Engineering Industries Ltd (AEIL) in Kampala.

Manufacturers prefer to work with development projects, of both government and non-governmental organizations, on a batch production basis. Traditionally there has been little contact with the end users. The FAO–TCP/UGA/2903 project sought with little success to change this situation by involving all stakeholders, including private manufacturers, through community demonstrations, field days and technology fairs. Local private manufacturers' fears include the fact that they do not know how much demand there is for these products so feel that commercial production is too risky without a firm order from an intermediate organization.

In the long run, farmers must buy the tools and equipment adapted for conservation agriculture. A realistic appraisal of the purchase cost was not available and has not yet been clearly thought through with farmers. Before such costs can be estimated with accuracy the practices have to be introduced and tested and conservation agriculture equipment adapted and manufactured by suppliers. Only then can farmers be sure that they will be able to afford the initial outlay and that the increased output will cover the ongoing costs.

Farmer field schools for introducing conservation agriculture practices and principles

Though the farmer field schools approach requires much effort to establish, it clearly strengthens farmers' voice for advocacy and enhances their ability to demand services and assess value for money, which is in line with the Uganda government plan for modernizing agriculture.

Farmer field schools were strengthened by providing training in group dynamics, registering the schools and developing constitutions. These steps have built farmers' confidence and trust. The community itself is now able to form second-generation schools and district farmer field school networks.

Farmers preferred the training method using short modules (appendix 1) as this allowed them to carry on with their daily activities. Trainers should provide handouts and training guides for future reference, especially for farmers who qualify as trainers. Unfortunately, such materials were not available in this pilot project. Materials should be in English and local language of farmers' choice.

Resource mobilization—savings, revolving funds and loans

As much as farmers yearned for knowledge, acquiring an income played a big role in strengthening the groups. Farmers appreciated the fact that the conservation agriculture–farmer field school project tried to address their economic needs by

setting up a revolving fund. Credit institutions existing in the areas do not favour agricultural enterprises, especially when they consider the long repayment period. The risks and uncertainties involved in agricultural enterprises prevent farmers from gaining access to credit or make them ineligible for loans at reasonable commercial interest rates. Having access to a group revolving fund increased the interest of participating farmers in conservation agriculture and enabled them to adopt its technologies. Field school farmers were also eager to take out individual loans.

Although the farmers groups made their own decisions on how to implement and repay loans, the field schools still need to work out strict repayment terms to avoid high repayment failure, which would lead to the revolving fund collapsing and the field schools disintegrating.

Farmers deposit group savings weekly to raise funds for their respective groups. Some field schools have also devised other ways to raise funds weekly for individual members. This has strengthened the groups; some members wanted individual loans for own activities and this is being addressed by group effort. The capacity of field schools to mobilize their own resources is a good initiative that deserves to be strengthened and replicated by others.

Farmers perceive field school membership, the farmer field school network, local councils and the local government as important avenues for scaling up conservation agriculture activities. These are interlinked, especially when it comes to drawing up work plans and budgeting. The bottom-up planning system adopted in the district could easily support conservation agriculture activities if grassroot farmers can get their requirements incorporated into the subcounty action plans.

Policy issues

The land-tenure system where land, especially on the hills and in the valleys and swamps, is owned communally and where other farmers hire land, makes it difficult for some farmers to practise and invest in conservation agriculture on such land as they do not have security of tenure.

All the conservation agriculture–farmer field school development initiatives documented in this case study are supported by donors. The measures they have put in place to ensure sustainability and to scale up are limited. Consequently, without government investment and support the programmes and projects are likely to collapse almost immediately once donor support is withdrawn. Therefore, wider scaling up of these initiatives at national level is needed through links with the National Agricultural Advisory Services (NAADS) programme and other development partners including the private sector and NGOs.

6 Conclusions and recommendations

The following recommendations need consideration:

- The farmer field schools need to be strengthened to make them self-reliant, improve access to conservation agriculture tools and equipment and other inputs, and encourage establishment of facilities like micro-finance to help farmers purchase the required tools and equipment.

- The three pilot districts should use farmer field schools structures, experiences and success stories to advocate school development and mobilize communities in that direction.
- MAAIF through NAADS should consider turning the pilot project into a programme and extending it to other subcounties within the pilot districts, and to other districts.
- The pilot districts should consider including conservation agriculture–farmer field schools in their annual budgets at all levels (district and subcounties) to continue and sustain the initiatives.
- Conservation agriculture–farmer field schools should carry out campaigns in the country to sensitize civic leaders and the entire public about the role they play in modernizing agriculture and in protecting the environment.
- MAAIF/NAADS and FAO should mobilize funds to produce the training manuals of the conservation agriculture–farmer field schools so that the NAADS extension service providers can disseminate them.

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Appendix 1 Curriculum for conservation agriculture–farmer field schools

Period	Topic	Contents	Practical exercise(s)
<i>Pre-experiment phase: Before the first rain season starts (preferably December–March)</i>			
Weeks 1–2	Farmer field school (FFS) methodology	Concepts and principles of FFS Steps in establishing a FFS Organization and management of FFS	Energizer development Music, dance, drama Group dynamics
Weeks 3–7	Participatory diagnosis of constraints and opportunities (PDCO)	Tools for PDCO Problem prioritization analysis Solution prioritization analysis	Transect walks Resource maps Institutional diagrams Problem trees, etc.
Weeks 8–9	Community action planning (CAP)	Problems/potential solutions synthesis Participatory selection (agreement) on specific constraints to address with specific technologies, within project mandate Selecting commercial enterprise What, who, when, where, how to do	Community and individual household dreams Visioning
Weeks 10–11	Participatory technology development (PTD)	Objectives and rationale for PTD Designing on-farm experiments Selecting test crop Reviewing constraints Treatment and technology Monitoring and evaluation of experiments	Field experimental design and layout

Exposure/field visit to a functioning FFS to observe group dynamics and application of PDCO, CAP, PTD

Experimental phase during which the study crop is growing, from planting to harvesting, processing and storage

Period	Topic	Contents	Practical exercise(s)
Weeks 12–13	Agroecosystem analysis (AESA)	Principles and concepts of AESA Developing participatory monitoring and evaluation (AESA) indicators	Making observations in the field on crop growth cycle, soil improvement, etc.
Weeks 14–15	Soil properties and functions	Physical Chemical Biological	Simple, field soil testing
Weeks 16–17	Local indicators of soil quality (LISQ)	Terminologies/ language to describe soil processes and characteristics	Field observations of LISQ
Weeks 18–19	Land-use planning	Land suitability classification	Farm tour
Weeks 20–24	Agroforestry (AF)	Role of AF in managing the environment AF shrubs and trees for improving soil fertility Tree nursery establishment and management AF technologies (fodder banks, woodlots, improved fallows, etc.) Fruit tree establishment and management	Setting up a tree nursery Grafting fruit trees
Weeks 25–26	Crop husbandry	Pest and disease management Agronomic practices	Field identification of soil-borne diseases
Weeks 27–32	Conservation agriculture principles and concepts	Tillage systems Cover crops Weed management Soil and water conservation Conservation agriculture (CA) farm machinery and power The catchment approach	Field observation of cover crops Practical handling of conservation agriculture tools and equipment

Period	Topic	Contents	Practical exercise(s)
Exposure through field visit to a functioning FFS, research station, individual farmers, etc. to see success stories			
<i>Post-experiment phase: after experimentation, and includes period after FFS graduation</i>			
Weeks 33–34	Adoption and adaptation of conservation agriculture	Challenges to adoption and adaptation of conservation agriculture in farming systems Cost–benefit analysis of conservation agriculture technologies	Microcatchment transect walk
Weeks 35–36	FFS networking and advocacy	Importance of FFS networking	Exposure visit
Weeks 37–38	FFS sustainability and scaling-up	Revolving fund	Exposure visit
Weeks 39–40	Market research	Group marketing	Market visit
Weeks 41–42	Graduation of FFS	Review of what has been learned Challenges, learning process and way forward Graduation preparations	Party
Exposure or field visit to a second-generation FFS to see success of adoption, adaptation, networking and sustainability			

Appendix 2 Checklist for household and group case study interview

Checklist for household interview

- A. Location
District:..... Subcounty:.....
Parish:..... Village:.....
- B. Farm household type
Name of household head..... Sex.....
Number of household members.....
Number of household members involved in agriculture:.....
Highest educational level in household:.....
- C. Asset base
- a. Physical capital (buildings, tools, machines).....
 - b. Natural assets (land, water, forests-woodlot).....
 - c. Social assets (groups, associations).....
 - d. Financial capital (access to credit, savings, remittance, goats, cattle, chickens)
- 1) What was your understanding of the conservation agriculture project's purpose?
 - 2) Have there been any changes in your expectations of the project over time? If so, in which way?
 - 3) What CA–FFS technologies and practices were you trained in? (give examples of what you have learned)
 - 4) What do you think were the most relevant conservation agriculture technologies and practices to your situation among those you learned? Why?
 - 5) Which technologies and practices do you consider not very relevant to your situation? Why?
 - 6) How was knowledge and information about the project shared among household members?
 - 7) What have you managed to adopt or adapt among the technologies and practices learned? Any indicators?
 - 8) What problems has the household experienced in implementing conservation agriculture practices and technologies? How can these be solved?

- 9) What was your main farming system (technologies and practices) before practising conservation agriculture?
- 10) In what ways has conservation agriculture affected or will affect your land management, and hence farming system?
- 11) Are there any changes and effects experienced on livelihood (food security, income levels, basic needs access) as a result of practising conservation agriculture?
- 12) In what ways has the conservation agriculture project affected or has potential to affect sociocultural patterns and perceptions? (gender and social relations)
- 13) What specific assets and capital does your household own that are relevant for the adoption and adaptation of conservation agriculture? (Any problems with the assets or capital experienced?)
- 14) What tools and equipment demands are necessary to adopt and implement the new conservation agriculture technologies and practices?
- 15) In what ways can the household acquire the necessary capital, tools and equipment?
- 16) How do you think your neighbours and other community members who are not members of the FFSs/CIGs will adopt conservation agriculture technology?
- 17) What have been the effects of adoption of conservation agriculture technologies and practices on:
 - a. Gender and age-group relations: labour, time, culture, resources
 - b. Enterprise (crop–livestock) selection and mix
 - c. Social relations within the community
- 18) How do you think you are going to adopt and continue the conservation agriculture activities on your farm? What opportunity exists?
- 19) What negative benefits or effects have you observed so far as a result of practising conservation agriculture? (cause, reason)

Appendix 3. Checklist for focus group discussions

- A. Farmer group identification
Name of group.....
Number of members: male....., female.....youth.....
Date of formation.....
Group goal, mission, vision.....
- B. Farmer group knowledge of conservation agriculture principles and concepts
1. How did you come to know about conservation agriculture?
 2. What does conservation agriculture mean to you?
 3. What are your roles and responsibilities in implementing the conservation agriculture project?
 4. Who are your partners and what are their roles and responsibilities?
 5. What conservation agriculture technologies and practices have you learned and adopted?
 6. What conservation agriculture technologies and practices have you learnt BUT NOT adopted? Why?
- C. Group benefits/effects as a result of practising or adopting conservation agriculture
- a. What have been your benefits and fears about conservation agriculture? (household, group and community benefits and fears)
 - b. What benefits do you hope to achieve from conservation agriculture in future, for example in 5 to 10 years' time?
 - c. What changes have occurred within and around the group as a result of practising conservation agriculture?
 - d. What general changes have occurred that were not planned?
 - e. What are the unintended or unexpected benefits or changes?
 - f. What are your fears or perceived threats about conservation agriculture?
- D. conservation agriculture continuity and sustainability
1. What opportunities exist within the group or community for continuity of conservation agriculture initiatives?
 2. What organizations and institutions exist in the community that have potential for further promoting?
 3. How can conservation agriculture initiatives be scaled out to the entire community? What will be your roles and responsibility?

Appendix 4 Reference framework

Based on the activities developed in the early stages of the project, the following questions appeared critical for structuring the framework around which all case studies would be based. They are grouped under three overarching headings:

- **Specific technical aspects related to conservation agriculture systems**
 - What are the key obstacles, challenges and way forward for controlling weeds in conservation agriculture?
 - Under what conditions does conservation agriculture lead to saving farmers labour?
 - What are the key obstacles, challenges and way forward related to crop–livestock interaction while using and adopting conservation agriculture systems?
 - What are the key obstacles, challenges and way forward for conservation agriculture in low-rainfall (semi-arid) areas?
- **Conservation agriculture learning and adoption processes**
 - What does it take to ‘learn’ conservation agriculture, both individually and collectively (activities, processes, etc.)?
 - What influence does the mindset of farmers, technicians and researchers have on adapting and adopting conservation agriculture practices?
 - What are the relative roles of technology transfer and local adaptation in gaining large-scale adoption of conservation agriculture systems?
 - What are the entry points and pathways that lead to large-scale adoption of conservation agriculture? Are some more effective than others?
 - Have large-scale farmers a comparative advantage in adopting conservation agriculture? What advantages and why? Under what conditions can conservation agriculture work for smallholders and resource-poor households?
 - What are the key lessons learned in scaling up adoption? Do’s and don’ts, and why.
- **Generic description of the conservation agriculture project**
 - Biophysical, socio-economic and institutional environment of conservation agriculture work.
 - Trajectory of related work in the selected region, site, project.
 - Overview of the conservation agriculture adaptation and diffusion process.
 - Conservation agriculture impact.
 - Present gaps and challenges in conservation agriculture work.



Busano, Mbale microcatchment



Conventional practice—hand



Petete, Pallisa microcatchment



Soil cover (mucuna) sprayed with herbicide then planted



Bisheshe, Mbarara microcatchment



Soil cover (mucuna) knocked down by oxen-drawn knife-roller before direct planting



Kasimire plants in a mulch with a planting stick locally known as a 'jobbe' Bisheshe, Mbarara



Farmers plant a demo with a stick in a mulch in Busiu, Mbale



Demonstrating direct seeding with Triton planter using oxen



Demonstrating calibration of a Triton planter



Conventional planting using a hand hoe



Demonstrating direct seeding using a jab planter



Maize at one week after planting in a permanent planting station



Farmers in Bulumbi FFS learning how to use a jab planter



Banana interplanted with mucuna cover crop and well managed



Banana interplanted with mucuna cover crop but not well managed



Banana/coffee interplanted with mucuna cover crop and well managed



Vanilla interplanted with mucuna cover crop but not well managed



Newly established banana in pits constructed in trenches



Permanent narrow-based terraces planted with onions



An established banana plantation with mulch



A typical vegetable crop-rotation field (beans and cabbage) on permanent narrow-based terraces, Busano, Mbale



Preparing permanent narrow-based terraces ready for planting



Cotton interplanted with canavalia-compatible association



Cotton interplanted with canavalia; cotton was completely suppressed



Cotton interplanted with Cajanus cajan, a compatible association



Maize intercropped with Cajanus cajan, both providing food



Banana interplanted with pumpkin, both providing food



Farmers and extension facilitators together plan a demonstration and experiment in Sapiri, Pallisa District



A farmer field school in Bisheshe; learning how to construct planting pits for banana



A three-size set of animal-drawn knife-rollers adapted by AEATRI, the Agricultural Engineering and Appropriate Technology Research Institute



Local artisans at work in Kibuko village, Pallisa