Conservation agriculture as practised in Ghana

Ghana

Philip Boahen, Benjamin Addo Dartey,
Genevieve Delali Dogbe, Emamanuel Asare Boadi,
Bernard Triomphe, Soren Daamgard-Larsen,
John Ashburner

CONSERVATION AGRICULTURE IN AFRICA

Conservation agriculture as practised in Ghana

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John Ashburner

Publishers
African Conservation Tillage Network (ACT)
PO Box 14733, Westlands
Nairobi 00800, Kenya
tel and fax: +254 20 445 1391
website: www.act.org.zw

Centre de Coopération Internationale de Recherche Agronomique pour le Développement (CIRAD)
42 Rue Scheffer, 75116 Paris, France
tel: +33 4 67 615800
website: www.cirad.fr

Food and Agriculture Organization of the United Nations (FAO)
Viale delle Terme di Caracalla
00153 Rome, Italy
website: www.fao.org

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Contents

Figures

Tables

Abbreviations

CA	Conservation Agriculture
CRI	Crops Research Institute
FAO	Food and Agriculture Organization of the United Nations
GHC	Ghana cedi, valued at 9100 to USD 1 in this booklet
GTZ	German Development Cooperation
IITA	International Institute of Tropical Agriculture
LWMP	Land and Water Management Project
MOFA	Ministry of Food and Agriculture
NGO	non-governmental organization
SARI	Savannah Agricultural Research Institute
SFSP	Sedentary Farming System Project
SLM	sustainable land management
SRI	Soil Research Institute
SRMP	Savannah Resources Management Project
USD	US dollar

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
Soren Damgaard-Larsen, RELMA

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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 Ghana. 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.

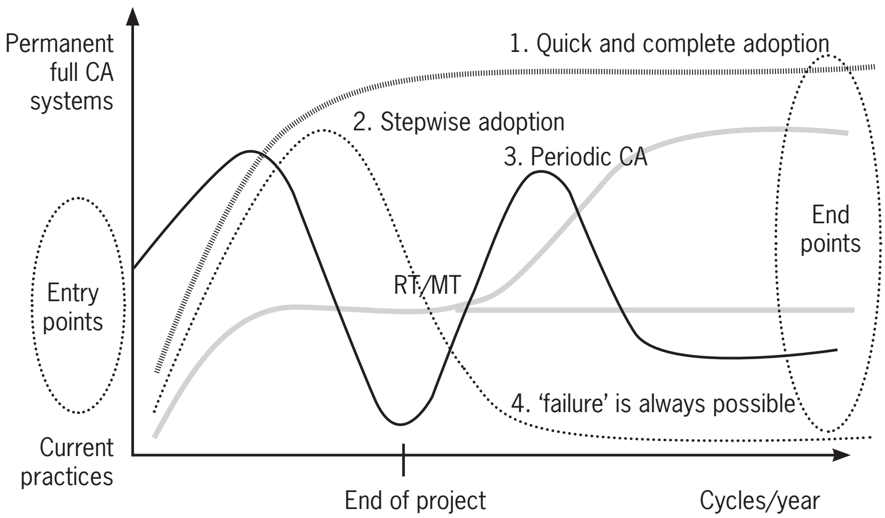

Figure A. Entry points and four hypothetical pathways towards adopting conservation agriculture:

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 projects[2] 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

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 programme[3] of the Global Forum for Agricultural Research (GFAR), WOCAT[4] and Sustainet.[5]

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individual ongoing projects in a region or a country, or to a succession of projects having 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 Sustainet website: http://www.sustainet.org

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.

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 in 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 3 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 development[6]
- 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 agriculture[7]

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.

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.

- Organize a mid-term review involving the local case study team, resource persons and project coordinators:
    - Review progress, difficulties, and preliminary findings.
    - 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 – Selian 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 times[8] 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 proactive 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 Ghana. 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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Executive summary

Traditional farming practices have not significantly improved crop yields or overall food production. In Ghana, fire is still used for clearing land, which has reduced soil organic matter and resulted in low productivity.

Conservation agriculture is a practice that reduces soil erosion, sustains soil fertility, improves water husbandry, and increases crop output for small-scale farmers. Experiments with no-tillage, minimum tillage and the use of cover crops have been ongoing since the early 1980s with support from a number of organizations, projects and programmes, with mixed results in technology adoption, adaptation and impact.

This booklet is an account of conservation agriculture and contributes to understanding its introduction, adaptation and diffusion in Ghana.

Twenty-one communities from Sunyani District in Brong Ahafo Region and Atwima District in Ashanti Region were involved in the study. Participatory rural appraisal tools were used and literature reviewed.

In introducing, adapting and diffusing conservation agriculture processes, a number of organizations and projects including the German Technical Cooperation (GTZ), Danida, Sasakawa Global 2000, Monsanto and the Ministry Food and Agriculture (MOFA) jointly implemented various projects through the MOFA extension system.

The conservation agriculture practices introduced and promoted in the study areas include slash-and-mulch without burning, use of cover crops, and minimum tillage with herbicides and direct planting. Use of herbicide was high compared with other practices like cover crops.

Conservation agriculture positively affected crop yields, labour use, weed control and farm incomes. But adoption of technologies declined after the donor-led projects closed down. Certain preconditions were identified as necessary for adoption of the promoted practices. These include long-term access to land and availability of inputs, especially cover crop seeds and appropriate conservation agriculture implements. Others include extension and institutional support for wider adoption of conservation agriculture to take place.

The case study team observed that promoting and using a multipurpose cover crop has the potential to enhance the adoption of cover crops, reducing heavy reliance on herbicides for weed control.

1 Introduction

Background and justification

Policymakers and researchers are alarmed by the fact that world food production does not grow at the same rate as the population. The gap between the growth in agricultural production and growth in the world population is widening each year. This gap is widening especially in African countries, where the population is growing annually at a rate of about 3% while food production is lagging behind with a growth rate of 1–2%. In spite of this gap, it has been stated that although soil fertility is declining worldwide, high levels of food production can be maintained with increasing inputs. The fertility of tropical soils declines at a rate that is even higher under conventional production techniques than soils of temperate climates (Steiner 2001).

In Ghana, the majority of farmers still use shifting cultivation and fire for clearing land. Simple tools like a hoe, cutlass (machete) and stick (dibbler) are the main ones used for planting. These labour-intensive production methods limit the area under cultivation and are responsible for severe yield losses because planting, weeding, harvesting, transport and storage are not carried out in time. The slash-and-burn system is no longer appropriate; reduced fallow periods due to increased pressure on agricultural lands lead to gradual soil degradation and declining soil fertility. Thus dependency increases on external inputs such as mineral fertilizers. The tedious fieldwork and low returns to labour make agriculture increasingly unattractive for the youth, resulting in migration from rural areas into the urban centres in search of non-existent jobs.

Conservation agriculture is a practice that reduces soil erosion, sustains soil fertility, improves water management and reduces production costs, making inputs and services affordable to small-scale farmers. Conservation agriculture is defined as a set of practices aimed at achieving the following three principles simultaneously:

- maintaining adequate soil cover
- disturbing the soil minimally
- ensuring crop rotation and intercropping

Farmers have been practising conservation agriculture as part of their traditional land preparation technique for several decades in Ghana. This system of land preparation involves clearing vegetation and allowing residue to rot before planting directly through the mulch. In most cases, crops are grown in association.

Experiments with no-tillage, minimum tillage, and the use of cover crops have been ongoing since the early 1980s with support from a number of organizations, projects and programmes. Results in technology adaptation, adoption and impact have been mixed.

Objectives of the study

The overall objective of this study was to improve the understanding of past and current conservation agriculture experiences in Ghana.

Specifically, the objectives for Ghana were as follows:

- identify and explore the process of introducing and promoting conservation agriculture
- identify and assess what has accounted for the success or otherwise of the practice of conservation agriculture
- identify opportunities for further promotion of conservation agriculture
- This study was developed around a unified, collectively agreed and locally adapted framework focusing on key issues and lessons learned, as well as on shortcomings and successes (see appendix 3).

The booklet is organized into nine sections: 1) a short introduction giving a background and objectives of the study; 2) methods describing the work methods and the tools used in collecting data; 3) overview of the case study areas; 4) a snapshot of past and current developments of conservation agriculture in Ghana; 5) description of conservation agriculture technologies as practised in the study areas; 6) conservation agriculture adaptation and diffusion processes; 7) adoption and impact; 8) discussions; and finally 9) gaps and challenges of conservation agriculture in the study areas.

2 Methods

How the case study framework was developed

A workshop was organized in Nairobi, Kenya, from 28 January to 4 February 2005 to develop a common framework to be used for the various field studies. The framework consisted of number of key issues and appropriate methods of collecting data to address them. This framework was jointly developed and agreed upon by other case study teams from different countries.

Desk study

An extensive literature search was conducted after a local case study team was constituted. The team consisted of the author and three students from the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. The literature, mostly of the grey type, included relevant project documents, progress reports, evaluation reports, impact assessment reports, articles and handouts, annual project plans and technical reports.

Although the focus was on conservation agriculture, the annual reports referenced highlighted overall project performance, and it was difficult to delink information related to conservation agriculture from general project information. For example, evaluation and impact assessment reports gave adoption figures on a global scale, showing overall project performance with little emphasis on conservation agriculture. Also, it was difficult to find a report covering all conservation agriculture elements extensively; most reports tended to be general, touching on only some aspects of conservation agriculture.

Selection of case study sites

The case study districts were selected keeping in mind past and current work related to conservation agriculture in those districts. A conscious effort was made to select communities that had directly benefited from these projects, communities that had not directly benefited, and communities that were believed to have spontaneously adopted elements of conservation agriculture technologies promoted in the district (see appendix 1).

Stakeholder analysis

To understand and incorporate stakeholders' perspectives into the case study, a stakeholder consultative workshop was organized, attended by 26 people (table 1). This workshop also verified and complemented data collected from literature, key informants and other farmers. Relevant and interested stakeholders took part in field visits.

The workshop brought a number of conservation agriculture practices to the fore and helped identify who could provide relevant information, thus linking the case study team to key informants.

Table 1. Attendance at stakeholder meeting

Name of stakeholder	Attending (no.)
Sasakawa Global 2000	3
Extension officers in Atwima and Sunyani Districts	6
Land and Water Management Project (former staff)	3
Sedentary Farming Systems Project	2
Soil Research Institute (SRI)	1
Crops Research Institute (CRI)	1
Farmers	6
University of Science and Technology	1
Agricultural input dealers	2
Ecorestoration, a local NGO	1

Key informant interviews

This study's approach explored and made use of a number of key informants— lead farmers, project staff (former project staff for projects that have ended), agricultural extension officers, and researchers from the Crops Research Institute and the Soils Research Institute. The team also visited agro-input dealers, both wholesalers and retailers, in Kumasi and Accra.

The key informants interviewed were selected through several means: through the stakeholder workshop, based on the author's knowledge about relevant stakeholders, and through community discussions.

Focused community group discussions

In all, 21 communities were visited in the two selected districts to conduct focus group interviews. The following criteria were used during the selection:

- communities in which most of the conservation agriculture-related projects had worked
- communities where no active conservation agriculture promotion had taken place
- communities where conservation agriculture had spontaneously been adopted

Community meetings were organized by the extension officer in charge of operational areas under which the selected communities fell. He informed the community about the purpose of the case study team's visit and subsequent field visits, and mobilized mostly members of existing conservation agriculture groups for the meeting. The extension officer facilitated community meetings, with a member of the case study team asking interview questions and two case study team members taking notes.

After this, field visits were conducted to observe farmer conservation agriculture practices. In most of these communities, farmers proposed which farm to visit. In all, the case study team visited 21 communities and interacted with 193 farmers, 68 of them women, in focus group discussions (see appendix 2 for list of communities visited).

Farm visits

The team visited a farm in all but four of the communities and observed fields where cover crops and minimum tillage had been applied. They observed visible improvements in soil fertility and the effect on weed growth.

Data analysis

At the end of each meeting key facts and observations were recorded and discussed. Information that the case study team verified was correct, coherent and consistent was added to relevant sections of a progress report. This helped in checking how facts gathered and put in the report answered the case study framework, in identifying gaps and in focusing the data collection to meet the relevant information needs.

Quantitative data obtained were analysed using simple Excel spreadsheets.

3 Study area

General information about Ghana

Ghana is located between latitudes 4°44' and 11°15'N, and longitudes 3°15'W and 1°12'E with a total land area of 238,500 km^2. Out of this land area, 57% (13,628,179 ha) is currently classified under agricultural use (Amanor 1993).

The country shares borders on the east with the republic of Togo, on the north with Burkina Faso and to the west with Ivory Coast (fig. 1). Ghana has 10 administrative regions: Upper East, Upper West, Northern, Brong Ahafo, Ashanti, Eastern, Western, Central, Volta and Greater Accra. The national capital is Accra, located in the southern part of the country.

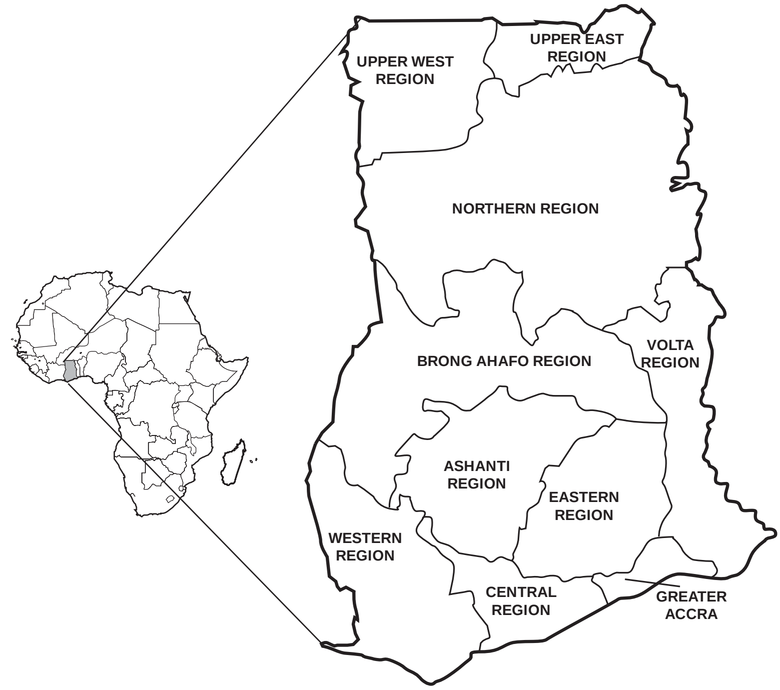

Figure 1. Administrative regions in Ghana.

Biophysical conditions

Based on climate and vegetation, Ghana is divided into six agroecological zones: Sudan and Guinea savannah zones (which form the northern sector), the forest–savannah transition and semi-deciduous forest zones (which form the middle sector), and the high rainforest and coastal savannah zones (which form the southern sector) (Bonsu 1996).

Socio-economic conditions

In March 2000, the population of Ghana was 18.4 million people. Population distribution varies across the country's ecological zones with the savannah zones, which are the most susceptible to desertification, carrying about 51%: 33.25% in coastal savannah, 13.3% in Guinea savannah, and 4.5% in Sudan savannah (EPA 2003).

Table 2. Climatic characteristics of different agroecological zones of Ghana

Ecological zone	Mean annual rainfall (mm)	Temperature (^{o}C)		Mean annual relative humidity (%)
		Mean max.	Mean min.	
Sudan savannah	1000	34.5	22.3	54
Guinea savannah	1000	33.6	22.3	61
Forest savannah transition	1000	32.5	22.6	70
Semi-deciduous	1500	30.6	21.1	76
High rainfall	2200	29.3	23.4	84
Coastal savannah	800	30.4	22.9	80

Adapted from Bonsu (1996)

Greater Accra has a population density of 897 persons/km^2, Central 161, Upper East 104, Upper West 31 and Northern 21. Agricultural land availability per capita ranged from 1.56 ha in 1970 to 1.11 ha in 1984 and 0.74 ha in 2000. This implies an increasing pressure on the natural resource base, particularly soil (EPA 2003).

Poverty is pervasive in the country. Available figures indicate that in 1999, more than 40% of the population in half the regions lived on less than USD 1 a day, with the Upper East, Upper West and Northern Regions faring the worst.

Poverty is highest among subsistence farmers. It has been suggested that poverty is the main underlying socio-economic cause of land degradation as it limits the ability of the poor to adopt sustainable measures for farming.

The agricultural sector dominates the economy, providing approximately 45% of the country's gross domestic product, 65% of employment, mainly in the rural areas, and 50% of exports. The sector comprises five subsectors: crops other than cocoa (63% of GDP), cocoa (14%), forestry (11%), livestock and poultry (9%), and fisheries (5%). The sector accounts for over 55% of foreign exchange earnings and is responsible for meeting over 90% of the food needs of the country. Key activities in the sector are food crops and livestock, cocoa production and marketing, forestry and logging, and fishing. Cocoa is the most important single cash crop, providing a significant proportion of national revenue. Other food and industrial crops cultivated include maize, cassava, yam, cocoyam, pineapple, banana, plantain, pepper, cotton seed, cashew nut, cola nut, sugar cane, rubber, oil palm, tobacco and coffee.

Sunyani and Atwima Districts

Sunyani District in Brong Ahafo Region lies between latitude 7°55'N and longitude 2°30'W. It is located at an altitude of between 229 to 376 m (SDA 1995). The district has a total land area of 2488 km^2. The population is ethnically diverse, the migrant population contributing significantly. Indigenous population consists of the Akan-speaking Brongs and Ahafos.

Atwima District, also in Brong Ahafo Region, lies between latitudes 5°60' and 5°62' N and longitudes 1°52' and 1°9'W. It has a total land area of 356.47 km^2 and over 1000 settlements with a population density of 120 persons/km^2. Atwima District borders the Ashanti regional capital, Kumasi, and there is declining gradient of population density along its south-west axis (Atwima District Assembly 1996)

Biophysical conditions

Climate, vegetation and soil type

Both districts fall within the wet semi-equatorial zone of Ghana with a mean monthly temperature of between 23 °C and 33 °C (SDA 1995). Rainfall is bi-modal in both districts with a peak rainy season from the end of March to July and again from September to November, after a short dry spell in August. The annual precipitation is around 1300 mm for Sunyani, with Atwima ranging between 1400 mm and 1850 mm (Holland 1995; Atwima District Assembly 1996).

A baseline survey on farming systems (Zschekel et al. 1997) reported that in general soil characteristics in the study areas vary from well drained with high organic matter content in the forest area, to poorly drained with low organic matter content in the savannah belt.

Land-use and farming systems

The predominant land-management system in both districts is slash-and-burn. This involves clearing natural vegetation followed by a cropping period of 2–5 years. The land is then abandoned for varying periods for it to regenerate naturally over time; weed and pest cycles are also broken through this process. This land-management system is now unsustainable as land pressure has greatly increased in both districts, shortening fallow periods. The untenable nature of this traditional system of soil fertility management has prompted the search for alternative measures that will enhance soil fertility on a sustainable basis, while promoting an ecologically sound environment.

The fallow vegetation is mainly dominated by *Chromolaena odorata* although grasses like elephant grass (*Pennisetum* sp.) also predominate in some locations. *Chromolaena* has become a major weed that farmers have found difficult to control.

The traditional method of farming predominates. Human labour is employed throughout the production process, using simple implements like the hoe and the cutlass. Tractor services for land preparation are uncommon; most tractor services are for transportation and occasionally for shelling maize. Most farmers cultivate between 1.2 and 2.8 ha. Crop rotation is practised with mixed and relay cropping being predominant.

Certain aspects of conservation agriculture have been practised in both districts for several decades. Land preparation to establish cocoa farms makes use of a local concept called *proka*, literally 'leaving to rot or allowing to rot then adding'. With proka, farmers clear the land without burning and the mulch (and other crop residue) is left on the soil surface to decompo se. This, according to farmers, adds fertilizer (nutrients) to the soil and helps conserve soil moisture. Where primary forest is cleared, partial burning is sometimes done to reduce the biomass. With this system, part of the vegetation is burned, a process known by some farmers as controlled or cold burning. Farmers usually supervise this activity to ensure that much of the vegetation is left as mulch.

Maize (*Zea mays*), one of the most important cash crops, is either intercropped with cassava or grown as a sole crop. Other crops are grown across the districts; most important in terms of quantities and income generation include cassava (*Manihot esculenta*), plantain (*Musa sapientum*), cocoyam (*Xanthosoma sagittifolium*), vegetables (garden egg, tomato and pepper), oil palm and cocoa (fig. 2) (Amanor 1996).

Most farming households rear livestock. In terms of numbers, important livestock are poultry, sheep, goats, pigs and cattle, but farmers keep little and livestock keeping is generally not integrated with the cropping system (Zschekel et al. 1997). Animals generally graze on communal land, farmers' fields and crop residue.

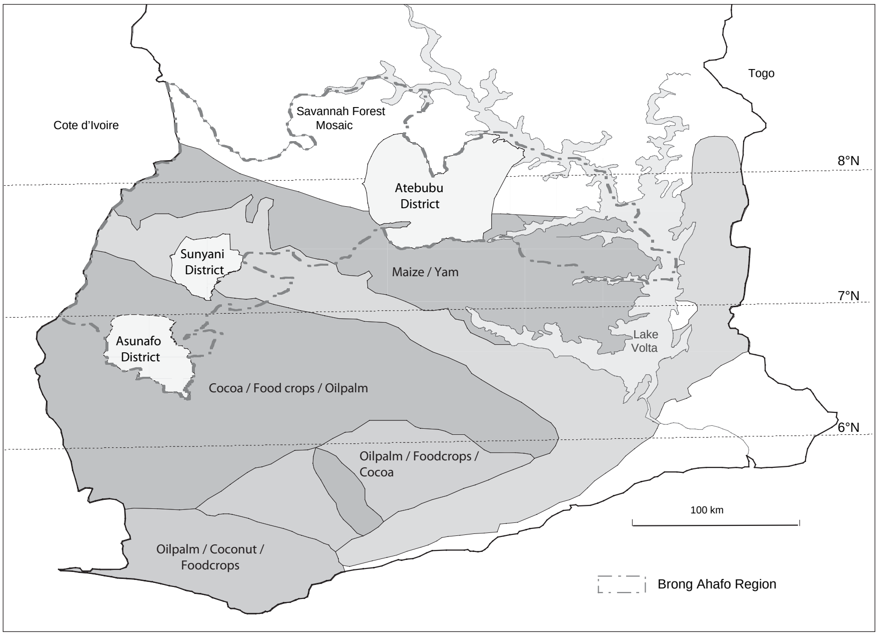

Figure 2. Farming systems in the project area (Zschekel et al. 1997).

Socio-economic conditions

Land tenure system

Customary land tenure arrangements prevail in both districts. Communal land-tenure systems and family land-tenure arrangements are the predominant tenure forms. Land ownership is normally held by the ruling families of the original settlers. Indigenous people, both men and women, have user rights to family land and generally do not rent land.

Family land tenure accords farmers user rights to the land they operate. Under this system, landholders have the right to bequeath land and to give out land on a contractual basis. Children can inherit land from their parents, in which case a piece of land is shared among the children. Land can also be rented for cash or on a sharecropping basis. The common terms used in sharecropping are *abunu* (produce is shared equally or 50 : 50) for yam and cassava, and *abusa*, where the tenant receives two-thirds of the maize and the landlord one-third.

The sharecropping system is predominant in Atwima, especially for most cocoa farmers. When cocoa is established, the caretaker can intercrop maize, cassava, cocoyam and plantain for subsistence until the cocoa matures. The plantain serves as shade for the young cocoa seedlings and plants. The landowner pays for the planting material—cocoa seeds or seedlings. Once the cocoa has established, the cocoa land is shared equally (50% each). The farmer is obliged to take care of the cocoa plants.

In communal land tenure, land belongs to the entire community. The paramount chief is the custodian of land and controls its allocation to farmers. This land cannot be leased or sold by individuals. In general, specific features of land tenure may cause barriers to long-term investment on the land. The family land-tenure system has led to fragmentation of holdings, while the communal system tends to undermine individual responsibility over long-term maintenance of a given piece of farmland and more emphasis is placed on shifting cultivation. In the renting systems of tenure, the temptation is immense to overuse the land to obtain maximum benefits in the limited time period.

Most communities are ethnically diverse, and migrant populations mainly from the north have contributed significantly to this. In both districts, the dominant tribe is the Twi-speaking Akan. The dominant Akan tribes are Ashanti in Atwima District and Bono in Sunyani.

The migrant population, referred to as settler farmers, mainly have sharecropping arrangements on a cash basis to plant vegetables with the few who have rented them the land.

Access to land and farm size

Average landholdings in both districts measure 1 ha. Most farmers cultivate plots of between 1 and 4 ha, especially for cocoa. Male-headed households have access to larger parcels of land than female-headed households. Traditionally, women's access is through the husband or the father. As it is assumed that men have more responsibilities than women because they have to look after the wife and children, they are more likely to be given larger areas to farm than the women (Zschekel et al. 1997).

Labour

Most farmers in both districts depend on hired labour for land clearing, planting, weeding and harvesting. High costs and shortage of labour during critical times are important production constraints, especially during weeding and harvesting (Zschekel et al. 1997; Frost 2001). Migrant labour from the northern part of the country is the main source of hired labour. Especially in Atwima District, people have migrated to the city in search of better jobs, and farm labour is in short supply during the cropping season. Migrant labourers from the north support preparing the land and planting in April then return to the north in May–June to start their own cropping season. Thus migrant labour cultivates and plants large areas but the workers are not available for weed control and harvesting.

The gender dimensions of labour for agriculture generally depend on the culture and traditions in different geographical locations. In Sunyani District, while men are solely responsible for land clearing and spraying agrochemicals, threshing and processing maize are mainly the responsibility of women. All other operations, such as planting, fertilizing, weeding, harvesting, storing and marketing produce are done jointly by men and women (Bonsu 2001).

In addition to working on the farm, female farmers are responsible for household activities like cooking, looking after the children and fetching water. They also engage in extra off-farming activities like trading and food processing to raise additional income. Off-farm income accounts for at least 30% of female household income (Zschekel et al. 1997).

Production and marketing constraints

The rainfall pattern, which affects planting time, has been erratic, sometimes reducing cropping from two to one cropping season per year. An increasing incidence of pest infestation has reduced yields and resulted in postharvest losses. Weevils and rodents are the main storage pests. Caterpillars, aphids, locusts and termites are the main field pests. An increasing weed load due to declining soil fertility has meant that more labour is required for weeding.

Input costs generally increased when subsidies on most agricultural inputs were removed, while prices of farm produce have declined, reducing profit margins. Farmers also expressed concerns about seasonal shortage of cash and lack of credit facilities. Those with access to credit complained about its inadequacy, high interest rates and bad timing of release.

With the exception of cocoa, which is purchased through organized marketing agents, most crops are produced, processed and marketed solely by the private sector. Middle women dominate the marketing chain from producer to retailer. Farmers (both male and female) sell some food crops at the farm gate while some are carried to the nearest marketing centre. Farmers usually complain about low prices offered for their produce. They view the margin obtained by these marketing agents as unreasonably high and think they should be narrowed by paying higher prices to the producers. High transportation costs, a poor transportation system, and poor market infrastructure are the main problems (Atwima District Assembly 1996; Zschekel et al. 1997).

4 Historical development of conservation agriculture in Ghana

Historical background

During a nationwide outbreak of fire in 1983, most cash crops such as cocoa and oil palm plantations were burned, and some farmers abandoned their fields (Vincent pers. comm.). Because it takes a number of years to re-establish plantation crops, interest shifted to cultivating food crops, mainly maize. Slash-and-burn became the main method of preparing land. This system was seen as sustainable because of the practice of shifting cultivation. Land pressure was low and farmers could afford to use this system to grow crops on fertile soils. Farmers used the land for only a short period, abandoned it and moved to other fertile land. The farmer then returned to that piece of land after several years of fallow, usually 7–10.

An increase in population with its attendant land pressure made shifting cultivation an unsustainable system of restoring soil fertility. The manifestations of slash-and-burn system were severe depletion of soil nutrients, increased weed load, on-farm erosion, and a general decline in yields (Kofi Boa, pers. comm.).

Land pressure forced a number of farmers to abandon the traditional system of shifting cultivation that was previously used to restore soil fertility. Declining yields, as a result of continuous cropping on the same piece of land with reducing fallow periods (from at least five years to a maximum of three years) made it necessary to search for technologies that would increase yields.

Research institutes, mainly the Crops Research Institute, the Soils Research Institute and the Savannah Agricultural Research Institute, responded to the government's call to search for other options by testing technologies such as minimum tillage, mulching, and use of cover crops both on station and on farm. Most of the research work started on station and later extended to farmers' fields for verification.

To promote the findings of on-station trials, the Ghana Grain Development Project, launched in the early 1990s, collaborated with Monsanto, Sasakawa Global 2000 and the Ministry of Food and Agriculture (MDFA) to promote minimum tillage and direct-planting techniques. The objective was to use plant mulch to address the low soil fertility and increasing weed problems. Herbicides were strongly promoted.

Programmes related to conservation agriculture

According to the Environmental Protection Agency (EPA 2003), conservation has always been an official concern in the management of natural resources in Ghana. It was realized early that Saharan conditions were threatening to encroach on the southern regions of West Africa. This encroachment was partly due to natural factors such as bush burning and erosion, and partly to human factors such as settlements and farming. This led to much thinking and action in forest management in Ghana during the first half of the 20th century. The programmes and projects in table 3 were implemented.

The Savannah Resources Management Project (SRMP) was a national programme that focused on developing sustainable land-management systems. It promoted the use of organic resources as a means of improving land resources. It did not have a strong conservation agriculture focus but contained elements such as keeping the soil covered using plant debris.

The Land Water Management Project started in 1995 as a component of the nationwide Ghana Environmental Resources Management Project. The project aimed at introducing and promoting improved land management practices within farming communities with emphasis on building MOFA capacity to provide adequate extension services on land management. Technologies promoted during the project included soil and water management techniques such as use of cover crops, minimum tillage and animal traction.

The no-till programme was jointly implemented by Sasakawa Global 2000 and Monsanto. It focused on promoting direct planting and using plant mulch that was derived mainly by using herbicides. The objective was to improve productivity by improving soil organic matter and reducing weed load.

The project also worked with input suppliers and credit agencies to address input problems that were seen as a precondition for successfully implementing the minimum tillage programme.

Table 3. Major programmes related to conservation agriculture implemented in Ghana

Name of project	Sponsors	Implementation partners	Component or focus	Operational area	Date
Savannah Resources Management Project (SRMP)	Danida	Ministry of Lands and Forestry	Rehabilitation of degraded soils Sustainable management and ownership of renewable natural resources	Northern, Upper East, Upper West, Ashanti, Brong Ahafo Regions	1992–??
Land and Water Management Project (LWMP)	International Development Agency (Danida)	Ministry of Food and Agriculture	Management of soil erosion, fertility and soil conservation	Ashanti and Brong Ahafo Regions	1995–2003
No-Till Programme	Monsanto and Sasakawa Global 2000	Crops Research Institute, MOFA, University of Development Studies, Dizengoff Gh Ltd	Glyphosate-based no-tillage farming for sustainable food production	National	1992–2005
Cover Crop Programme	IITA and Crops Research Institute	Crops Research Institute	Adaptive trial of cover crops	Ashanti and Brong Ahafo Regions	1996– ??
Sedentary Farming Systems Project (SFSP)	German Development Cooperation	GTZ, German Development Service and Ministry of Food and Agriculture	Promotion and use of cover crops, minimum tillage, integrated soil fertility management measures	Brong Ahafo Region	1996–2004
	SARI Nyankpala		Research on direct planting systems	Northern Region	1988–2004
	Churches + GTZ	Church NGOs	Promotion of minimum tillage and cover crops	Tamale District	1998–2004

The Cover Crop Programme was collaborative between the International Institute of Tropical Agriculture (IITA) and the Crops Research Institute (CRI). Leguminous cover crops such as *Mucuna*, *Pueraria* and *Canavalia* were screened on station and on farm. The Land and Water Management Project and the Sedentary Farming System Project made use of the findings of this programme in their extension work.

Promoted by the Sedentary Farming System Project, which operated in the Brong Ahafo Region, conservation agriculture consisted of improving the management of soil organic matter, rotating crops properly, using cover crops to improve short-fallow systems, and using animal manure. Supporting measures included improving access to agricultural services such as reducing postharvest losses, adding value to raw products through processing, and improving marketing opportunities.

Farmers, traders and other people involved in agriculture were the target group and beneficiaries of this project, which collaborated with the coordinators and field

Farmer focus group discussion at Tanoso, Sunyani District

Farm visit to farmer practising conservation agriculture by extension officer from the Ministry of Food and Agriculture

Vegetation in Sunyani District

Vegetation in Atwima District

Cajanus alley with mucuna

Planting through the mulch

Maize–mucuna intercrop

Canavalia–maize intercrop

Mucuna fallow

Mucuna fallow

Cover crop field sprayed with herbicide

Pueraria under oil palm

officers of Sasakawa Global 2000 and LWMP. Joint planning sessions were held and activities were jointly implemented as the objectives of these projects were similar, although funding came mainly from the Sedentary Farming System Project.

Institutional support for conservation agriculture

The National Conservation Agriculture Team is a working group that consists of representatives from MOFA (Crop Services Directorate, Agricultural Engineering Services Directorate, and Directorate of Agricultural Extension Services); research (Crop Research Institute, Savannah Agricultural Research Institute, and Soil Research Institute); universities (Agricultural Engineering Department of Kwame Nkrumah University of Science and Technology, University of Development Studies); international organizations (the World Bank, the Food and Agriculture Organization of the United Nations (FAO), German Development Cooperation (GTZ)); and other projects and companies (Food Crop Development Project, Monsato, Research Extension Linkage Committee) but has remained dormant for the past few years. The team was charged with coordinating conservation agriculture programmes in Ghana and with facilitating collaboration and building synergy among conservation agriculture practitioners. Individual projects provided funds for their representatives to attend meetings.

Currently, the conservation agriculture project is no longer active in Ghana, except for a few demonstrations sponsored by Monsanto for the purpose of selling Round-Up. Although the World Bank–supported Agricultural Services Subsector Investment Programme has removing drudgery and improving production methods through increased use of mechanization and engineering technologies as one of its objectives, little emphasis is placed on the principles of conservation agriculture. It also aims to make readily available better and more affordable tools and implements for increased production, but the appropriate tools needed to enhance adoption of conservation agriculture practices are largely unknown to the project coordination unit.

In late 2003, with support from the Sedentary Farming Systems Project of GTZ, the National Conservation Agriculture Team facilitated preparation of a proposal aimed at piloting successful conservation agriculture practices that have been locally adapted in other parts of the country and for possible scaling up based on results. The Technical Cooperation Project proposal was submitted to FAO in early 2004 for funding but the whole proposal stalled for lack of funding.

Although some experience and knowledge of conservation agriculture exist in Ghana, there is no conscious effort to promote it for large-scale adoption.

5 Conservation agriculture technologies

The conservation farming concept developed and promoted in the two districts is a merger of technologies originally promoted by IITA, the Crops Research Institute Kumasi, and Sasakawa Global 2000, complemented by the Sedentary Farming System Project project’s own research (Loos 2001).

The main practices identified in the study areas are summarized in table 4.

Table 4. Summary of conservation agriculture practices in the study area

Practice	Key elements	Principle	Stage	Institutions involved
Proka (local practice)	Slashing of vegetation and leaving it to rot	Soil cover	Practised only in forest zones to establish cocoa and oil palm plantations	
	Partial burning is done if biomass is too much and will disturb planting and germination	Minimum soil disturbance		
	Remaining biomass is left to cover the field and decompose			
	Planting of cocoa, and food crops as intercrop			
No-burning, slashing and mulching	Slashing of vegetation	Soil cover	On-farm experimentation and implementation	SFSP & LWMP
	Biomass left to serve as mulch	Minimum soil disturbance		
	No burning			
	Planting directly with dibbler			
Minimum tillage and direct planting	Land preparation done by slashing vegetation without any form of tillage	Minimum soil disturbance	Implementation	SFSP, Monsanto, SG2000
	Spray herbicide (glyphosate) after weed regrowth of about 30 cm height			
	Direct planting of maize, cassava or plantain through the mulch without burning			
Alley cropping with cover crops	Alleys established using fast-growing shrubs	Permanent soil cover	On-farm experimentation	IITA-CRI,
	Biomass harvested and used as mulch			SRMP
	Maize planted directly without burning			SFSP & LWMP
Crop rotation and intercropping with legumes	Intercropping or relay-intercropping of leguminous cover crops (e.g. *Mucuna*, *Canavalia*)	Permanent soil cover, minimum disturbance and crop rotation	On-farm implementation	SFSP, LWMP, IITA-CRI
	Harvest of main crop, cover crop left on the field as short fallow			
	Cover crop biomass protected from bush fires and excessive grazing			
	Direct planting without burning			
Cover crop (*Mucuna*) and herbicide	Cover crop established as a sole crop	Permanent soil cover and minimum soil disturbance	On-farm experimentation	IITA-CRI, SFP, LWMP
	Herbicide used to kill the biomass			
	Maize, vegetables, cassava or plantain planted directly			

[a] Implementation means that farmers have moved beyond on-farm experimentation and have extended or applied technology to other parts of their farms

No-burning, slashing and mulching

Under a system of no burning but slashing and mulching, farmers slash the vegetation with a cutlass or machete to prepare the land. The biomass or vegetation is left to dry to form mulch. Maize is planted directly through the mulch, which has not been burned. Planting is done manually using a dibbler or planting stick or a cutlass. Weed control is done manually using a cutlass or machete, or with a hand-held hoe. Fertilizer may be applied if cash is available. Pests and diseases are addressed through integrated pest management, using chemicals only if deemed necessary. This conservation agriculture technique is used for all types of crops, but in the case study sites, it was used predominantly on maize, cassava and vegetables. Within the season, farmers should benefit from soil water conservation and weed control through the presence of the mulch. In addition, the physical and biological properties of the soil are expected to improve after the mulch decomposes.

Minimum tillage and direct-planting techniques

Land is prepared by slashing the existing vegetation and allowing regrowth up to 30 cm height. A glyphosate-based herbicide—normally Round-Up, Chemosate, or Helosate—is sprayed with a knapsack fitted with a low-volume nozzle, using the following rates of application:

- 450 ml or 3 sachets for every 15 litres water for perennial weeds
- 300 ml or 2 sachets for every 15 litres water for annual weeds
- 15-litre knapsack for 100 m^2 or 8 knapsacks per hectare of land

The residue is left on the soil surface without burning, and the farmer waits for 7–10 days before planting through it. Direct planting is done in rows through the mulch using quality protein maize. Planting is done manually using a dibbler or planting stick. Maize is the main crop planted under this system; Sasakawa Global 2000 promoted planting okra and plantain under it. Farmers should benefit from soil water conservation and total weed control from the mulch. Preventing weeds from producing seeds results in a reduced weed seed bank and weed pressure is thus reduced over time. The fertility of the soil should improve after the mulch decomposes in the subsequent seasons.

Alley cropping with cover crops

Alleys are established using fast-growing shrubs or tree species such as *Cajanus cajan* (cowpea). A cover crop, mainly mucuna, is planted between the alleys to protect the soil and to control weeds while the cowpea grows. When the cowpea matures, the biomass is harvested and used as mulch. Maize is planted through the mulch directly without burning.

This technique is still under experimentation. Farmers practising it mostly own or have long-term access to the land. Besides maize, cassava and cocoyam have been planted under this system. Farmers benefit from the nitrogen that is introduced through the leguminous cover crops. Soil water is also conserved and weeds are controlled.

Crop rotation and intercropping

The rotations in figure 3 have been practised and promoted by farmers:

- Intercropping with legumes is strongly promoted under this practice. Farmers are encouraged to leave crop residue on the field as a cover.
- Under these systems, maize is planted in the major season in April and the cover crop is intercropped after six weeks in the case of canavalia, or relay intercropped at least eight weeks after planting to minimize competition.
- Maize is harvested and the cover crop stays on the field as the next crop in the minor season until the following major season.

Improved short-season fallow with leguminous cover crop

Mucuna, *Dolichos* and *Canavalia* are the main cover crops used during this short fallow. Major-season maize is planted around April and harvested in mid to late July or early August. The cover crop (*Mucuna, Canavalia* or *Dolichos lablab*) is planted as a minor-season fallow, from August to March. In the next major season beginning in April, farmers plant their crops (maize, yam, cassava or any other crop) through the mulch without burning. Weeding is done with the machete when necessary.

Where rainfall during the major season is not reliable, farmers plant the cover crop in it (April), and plant the food crop in the minor season (August–September).

Permanent cover under plantations

In a plantation system, a permanent cover is established with a crop such as *Pueraria* to control weeds and conserve soil moisture. This is normally practised by farmers cultivating plantation crops such as oil palm. To prevent vines from climbing the plants, ring weeding is done around the main crop.

Mucuna and herbicide

Where weed pressure from spear grass (*Imperata*) is very high, a combination of Round-Up (glyphosate) and mucuna is used.

The land is slashed to ground level and allowed to regrow to about 30 cm. Round-Up is sprayed and mucuna is established as a sole crop for the whole season. In the next season, maize is planted on the field. The biomass is protected from bush fires by creating firebreaks around the field. This can be a component of the techniques described earlier and is not necessarily a stand-alone practice.

A common feature of the described practices is the use of plant material or mulch to cover and protect the soil surface, a key component of conservation agriculture. However, in the study sites, different methods were used to achieve this. The sources of soil cover were cover crops, slashed natural vegetation, or herbicide.

In all, common implements, the machete (cutlass) and the dibbler, were used for planting. Planting was done manually; mechanical planting remains a reality yet to be achieved (see ‘Inputs’ in section 7).

<table>
<tr><th>Types of Intercrop</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
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<tr><td rowspan="2">Maize–cassava intercrop</td><td colspan="3">Land preparation</td><td colspan="2">Maize planted</td><td></td><td colspan="2">Maize harvested</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">Cassava intercrop</td><td></td><td></td><td colspan="4">Cassava remains for the rest of the season</td></tr>
<tr><td colspan="13"></td></tr>
<tr><td rowspan="2">Maize–cowpea intercrop</td><td colspan="3">Land preparation</td><td colspan="2">Maize planted</td><td></td><td></td><td colspan="4">Option 2: Cowpea planted after maize harvest</td><td></td></tr>
<tr><td></td><td></td><td colspan="5">Option 1: Cowpea planted after 4 weeks</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="13"></td></tr>
<tr><td rowspan="2">Yam–cowpea–maize–intercrop</td><td colspan="2">Yam planted</td><td></td><td></td><td></td><td colspan="2">Yam harvested</td><td></td><td></td><td></td><td colspan="2">Land preparation</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Cowpea</td><td></td><td colspan="2">Maize planting</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="13"></td></tr>
<tr><td rowspan="2">Maize–cassava–oil palm</td><td colspan="3">Land preparation</td><td colspan="2">Maize planted</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">Cassava intercrop</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="2"></td><td colspan="6">Oil Palm</td></tr>
<tr><td colspan="13"></td></tr>
<tr><td rowspan="2">Vegetables–maize–vegetables</td><td colspan="3">Land preparation</td><td></td><td></td><td></td><td></td><td colspan="3">Maize</td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="5">Vegetables</td><td></td><td></td><td></td><td colspan="2">Vegetables under irrigation</td></tr>
</table>

Rotations:

maize – cowpea – maize

maize-cassava intercrop – cassava – fallow

yam – maize – fallow

yam-cowpea-cassava intercrop – maize

maize-cassava-oil palm intercrop – oil palm

tomato or garden egg (eggplant) – maize – tomato or garden egg

plantain-cassava-maize-cocoyam intercrop – plantain – cocoyam – cassava

Figure 3. Crop rotation and intercropping in Atwima and Sunyani Districts

6 Adaptation and diffusion

On-station adaptive trial

Research institutions such as the Crops Research Institute and Soil Research Institute played an instrumental role in technology development and on-station adaptive trials. IITA supported the Crops Research Institute in the adaptive trials to screen various types and varieties of cover crops to introduce farmers. The Sedentary Farming System Project and LWMP also supported this work and further assisted in acquiring seed of different types of cover crops for screening on station.

The no-till programme supported on-station experimentation on different no-till systems, establishing the right time and techniques to use in applying herbicides.

Creating awareness in the community

All the projects used MOFA extension officers to sensitize communities to conduct on-farm trials. In the case of LWMP and the Sedentary Farming System Project, community awareness was done through the project's contact farmers with the extension officer serving as facilitator. Through this process, farmers identified key problems faced and how they had or proposed to solve them. During the search for solutions, cover crops were mentioned as one of the options that have the potential to improve soil fertility, reduce weed load and increase yields. Farmers are given samples of seeds of cover crops with supporting leaflets and posters.

On-farm trials are discussed with farmers and indicators are developed jointly to monitor and evaluate the various trials. Farmers are trained on various topics depending on the problems identified through using participatory rural appraisal tools like problem-tree analysis, cause-effect relationship, ranking and scoring. They are also trained in how to manage the trial, including monitoring and evaluation. Farmer training and extension advice are dealt with in much detail in the 'Training and extension advice' section below.

According to MOFA district offices in Atwima and Sunyani, farmer expectations vary; thus creating community awareness and support is critical to the success of the programme. If the technologies and interventions being proposed do not meet immediate cash requirements such as credit or inputs such as fertilizer, farmers tend not to be too keen on the demonstration. It becomes more difficult when they have to invest in the land for several seasons before getting benefits from the technology. The extension officers overcame this obstacle by using good communication skills and making the objectives of all meetings with farmers clear from the beginning, to level expectations. The no-till programme had an input component and served as an incentive for farmers to participate in field trials. Farmers with successful results were recommended to rural banks for credit.

On-farm trials

The Sedentary Farming System Project, LWMP, Monsanto and Sasakawa Global 2000 provided basic inputs such as cover crop seeds, herbicides and improved maize variety for the on-farm trials. Farmers helped design test plots representing the new or improved technology with a control plot representing the farmers' practice and provided sites for the trial. An important factor that farmers considered in locating trial sites was that they be accessible for other farmers.

Unlike LWMP and the Sedentary Farming System Project, the No-Till Programme made use of roadside demonstrations and did not solely rely on farmer groups. The Sedentary Farming System Project and LWMP focused on group learning processes and used the farmer groups as a vehicle for establishing what is known as group or community trials, a concept similar to the farmer field school. Individual farmers within a group were expected to establish their own demonstrations and apply whatever they learned from the group or community trial.

Training and extension advice

An important part of technology introduction and promotion was farmer group training (Asare Baffour, pers. comm.). Farmer training starts with sensitizing the community; it shows farmers how the technology works and how it can fit into their farming system. The agronomic and ecological benefits are explained when the technology is introduced.

Because the extension officers serve as facilitators, they received training from the project regarding the extension approach and the various technologies to be introduced. A number of training sessions were organized for the extension officers and others for farmers.

The agricultural extension agents were trained primarily so that they could conduct similar training with the respective farmer groups they were in charge of. Extension officers received training on participatory extension methods and the use of participatory rural appraisal (PRA) tools.

Training for farmers included the following content (SFSP, LWMP and No-Till Programme):

- Principles and practices of conservation agriculture
- Method of spraying herbicides
- Method of planting maize using lines and pegs
- Fertilizer application
- Integrated pest management
- Soil fertility management
- HIV/AIDS awareness creation
- Introduction to organic farming
- Dry-season feeding of lower ruminants
- Postharvest management of maize

Farm budget and record keeping

After the training, extension officers followed up with field visits to monitor field trials and to advise farmers. The extension officers mentioned that they visit farmer groups two times every week. However, farmers indicated that the frequency of extension visits was about once every week, and sometimes once every fortnight.

During farmer group discussions the case study team made the following observations regarding farmers' interactions with extension within the context of training events.

- Group meetings during training brought farmers together to learn and share ideas.
- The training helped farmers identify the causes of some of the problems such as how to handle pests and diseases and how to market produce in their communities; and look for the best way to solve these problems.
- Through the process, farmers now know the cropping calendar and are better placed to plan their farming operations.

As part of farmer training, the Sedentary Farming System Project and LWMP organized a number of farmer exchange visits. These visits allowed farmers to compare results obtained from their individual farms. The extension officers also used the occasion to explain how the technology worked and the problems that could be expected. Monitoring used the indicators developed during the start of the trial.

The No-Till Programme relied mainly on farmer field days, a forum that enabled researchers, extension officers and the farmers to jointly monitor and evaluate the technological options introduced.

Farmer demonstrations helped convince farmers in the project catchments area to start using herbicides and plant-based mulch because of their positive effects on weeds.

7 Adoption and impact

Adoption

Adoption rates

Accurate adoption figures within Atwima and Sunyani Districts were difficult to come by as these figures are reported as regional and national aggregates. The adoption data obtained from Sasakawa Global 2000 and LWMP were not coherent, with a lot of missing data and gaps, and therefore were not used. However, Ekboir et al. (2002) and an impact assessment report from the Sedentary Farming System Project give a rough picture of adoption.

The Sedentary Farming System Project's impact assessment report of 2001 (SFSP 2001) indicated an increase of more than 100% over 2000 in the number of participating farmers applying at least one of the described conservation agriculture practices in Sunyani District. In 2000 alone, 76% of all participating farmers were practising at least one of the techniques being promoted, and this increased to 78% in 2001. This does not necessarily mean adoption of conservation agriculture, as farmers can easily abandon these practices once a project comes to an end.

According to the Sedentary Farming System Project reports (SFSP 2002, 2003a,b), the total number of participating farmers increased significantly between 2002 and

2003, with at least 30% of practices extended from the initial trial plot size of 400 m^2. At least 35% of participating farmers have applied at least one conservation agriculture practice in two consecutive years and beyond, 28% of the farmers being women. Farmers indicated that the conservation agriculture practices are beneficial in lowering production costs and increasing yields.

Minimum tillage and direct planting demonstration plots with Monsanto increased from 170 in 1996 to 261 in 1997, 321 in 1998, 226 in 1999, and 440 in the year 2000 (Ekboir et al. 2002).

Preconditions for adoption

For a farmer to adopt a cover crop and use it, the farmer needs at least two years of user rights of the land to benefit from the investment made to improve soil fertility.

Criteria for choosing certain conservation agriculture practices

An analysis of reasons underlying the choice of a particular tillage system (table 5) showed that farmers farming their own land clearly preferred conservation agriculture practices. For farmers using hired land, an important determining factor is for how long the farmer has access to the land.

Table 5. Farmer preference for tillage practices as a function of the land tenure system, Sunyani District (%)

Land tenure system	Period (years)	Slash-and-burn (%)	Conservation agriculture (%)
Family land		20	80
Hired land (cash)	1	30	70
	2–5	20	80
	> 5	20	80
Hired land (sharecropping)	2–5	30	70
	> 5	30	70

Source: Adjei et al. 2003
Number of farmers = 67

Farmers with sharecropping arrangements preferred to practise conservation agriculture because their landlords encouraged them to do so, as they expected an increase in their share of the harvest crop. In other settler communities, however, the adoption of cover crops in maize production led to occasional conflicts between land owners and tenants about lease conditions. According to farmers in Kwaware in Sunyani District, landlords decided to take their land back from the tenant farmers when they saw improvements in soil fertility and general improvement in yield. The tenant farmers planted mucuna on the land for two years, and this improved yields by up to 25% in the third year. When a cover crop is planted the farmer is not able to benefit from improved soil fertility in the first year. Visible improvements are seen in the subsequent years as the plant residues decomposes and plant nutrients become available for use. The landlords decided to use the land themselves for crop production after seeing improvements in fertility and overall soil condition.

In Sunyani District, the motivation for farmers to adopt cover cropping is twofold: to improve soil fertility and to suppress weeds. However, others adopted with the idea of getting monetary benefits from the sale of mucuna seeds. Following farmers' interest in planting cover crops, the Sedentary Farming System Project arranged for mucuna and canavalia seeds from the pilot communities where initial on-farm trials were conducted. To motivate farmers to harvest and to properly store the seeds, the project purchased the seeds to supply to other communities. This led to spontaneous adoption, where farmers planted with the view of selling to the project.

Minimum tillage involving slashing and spraying with Round-Up has been adopted since 1996. Due to its positive effect on soil fertility, weed control and yields, farmer have continued to use this practice even after the projects ended but hardly any data exist to show the number of farmers using it.

The case study team observed that progress made in promoting conservation agriculture in the communities visited was mainly due to the influence of donor projects. Although most of these projects collaborated with MOFA, the agricultural extension officers indicated that the number of farmers using conservation agriculture practices dropped by an estimated 30% when the related projects ended. A major explanation is that the frequency of visits by extension officers to selected communities dropped from twice a week to once every fortnight once the project ended and the project no longer bore the associated costs, thus reducing interaction between extension officers and farmers.

In communities where conservation agriculture has not been actively promoted, the traditional proka was still being practised, but it was disrupted with burning from time to time. The practising proka farmers had, however, not heard of the use of cover crops, although about 30% of farmers interviewed had used herbicides before.

In the two communities where use was believed to have been spontaneously adopted, farmer cross visits seem to have been a major factor. After seeing the benefits from other fields, they decided to experiment on small plots, 10 m x 10 m, and later extended to an average land area of a quarter hectare. These visits were facilitated by lead farmers who travelled to these communities and came across technologies the extension officers were promoting in these communities.

Agronomic and environmental impact

Yields

Different projects and authors have reported an increase in yields after using conservation agriculture practices. Farmers have also reported increases in yields in the second year after applying at least one of the practices in the second year (table 6). As farmers rarely keep records, it is, however, difficult to get accurate data.

These results (table 6) further strengthen the claim that conservation agriculture practices are superior to a traditional practice like slash-and-burn. It is important to note that these results were achieved in the second year of continuous use of the technology.

Table 6. Maize yields achieved with selected conservation agriculture technologies

CA technology	CA yield (t/ha)	Slash-and-burn yield (t/ha)	Source
Cover crop (mucuna) with maize	1.8–2	1.2	Farmer records: average of 10 communities in Sunyani District
Minimum tillage and direct planting	3.0	0.75–1	Farmer records: average of 11 communities in Atwima District
Minimum tillage and direct planting	2.7	1.8	Bonsu (1996)

Positive results have also been achieved with slashing without burning, but higher yields were achieved by applying fertilizer to no-burn plots. In trials on 20 farms in the forest transitional zone, the conservation agriculture practice of slash-and-mulch gave yields of maize as 3.9 t/ha without fertilizer and 5.7 t/ha with it; slash-and-burn yields were 1.9 t/ha without fertilizer and 3.2 t/ha with it (Bonsu 1996).

Farmers mentioned that after burning the mulch from the previous year, crop yield was slightly higher than after preserving it. They furthermore indicated that fields that had been ploughed for a number of years recorded slightly lower yield when tillage was minimal and herbicide was applied. This was probably due to ploughing pans having been formed that made it difficult for crop roots to go through the deeper layers of the soil for nutrient uptake.

Farmers in communities where conservation agriculture has not been actively promoted were unorganized and could not produce any field records. However, the farmers visited indicated a yield of 1.2 t/ha, using traditional slash-and-burn.

Farmers revealed that planting crops through thick mulch with a machete was cumbersome, especially during the first year of such a practice. The work was a bit easier with a jab planter but depended largely on farmers' experience with its use. Farmers also confirmed that high amounts of soil cover impeded germination of the main crop and affected plant population, thereby affecting productivity. In such cases, partial burning appeared sometimes necessary to reduce the quantity of mulch on the field, to enhance germination.

Weed control

According to both MOFA extension officers and farmers, weed control has been effective under minimum tillage practice. In all conservation agriculture communities visited, farmers mentioned that one of the factors that influenced their decision to use this practice was the ability of cover crops and herbicides to control weeds. The practice reduced the number of weeding sessions by at least one.

The effect of mucuna on weed suppression was due to higher biomass and better soil cover. For example, Adade et al. (2001) reported that weed pressure was reduced by 75–90% after 8 to 10 weeks of incorporating *Canavalia ensiformis* into plantain. Noxious weeds of importance, which are easily controlled by *C. ensiformis*, include *Imperata* sp., *Commelia*, *Cyperus* sp., *Psida*, *Tridax*, *Centrosema*, *Panicum*. The succeeding weeds were not difficult to control by manual weeding.

Kwaware is a settler community in Sunyani District where farmers used cover crops to improve the soil fertility and crop yield. Yields doubled from 1.2 t/ha to 2.4 t/ha after mucuna was grown for three years as a minor-season fallow, followed by maize in the major season. Landlords evicted some farmers from their lands after seeing visible improvements in the soil, although they had shared cropping arrangements. A contrasting situation was observed in Nkawie in Atwima District, where landlords were happy to see improvements in the land because as the yield from such plots increased, it also improved their share of the harvested crop. Thus, depending on the situation and arrangements it can become difficult for farmers to use cover crops on their fields without possessing long-term access to the land.

In a research to assess the impact of *Mucuna* spp. on weeds in maize-based cropping systems, Boahen (2002) reported a big change in weed population when comparing the situations of a natural fallow plot and one where mucuna had been planted (table 7). In focus group discussions, farmers indicated that weeds such as *Euphorbia heterophylla*, *Commelina* sp. and *Pouzolzia guineensis*, found after mucuna, were easier to control than *Chromolaena odorata*, found under the natural fallow.

Table 7. Dominant weed species after cover crops

Treatment	Dominant weeds
Natural fallow plot	*Chromolaena odorata* *Sida* sp. *Synedrella nodiflora* *Axonopus compresus* *Cyperus* sp.
Mucuna plot	*Euphorbia heterophylla* *Commelina* sp. *Ageratum conyzoides* *Centrosema pubescens* *Pouzolzia guineensis* *Talinum triangulare*

Source: Boahen 2002

Case S: Achieving effective weed suppression using cover crops was not automatic, as about 30% of farmers who have used cover crops indicated weed reduction of only 40%. Effective suppression was linked to farmers' capacity to properly manage the cover crop biomass to obtain total ground cover. In particular, protecting the biomass or ground cover from bush fires during the dry season in December to March is critical.

Farmers in Atwima District indicated high effectiveness of herbicide on *Panicum*, and *Emelia* spp. They indicated that the broadleaf weeds that subsequently appeared after spraying did not pose any major problem to the food crop cultivated. The main secondary weed that appeared after spraying was *Amaranthus* spp., which is easy to control. According to the farmers, this could be controlled by applying a postemergence herbicide or by hand pulling. It was observed in non-conservation agriculture communities that some farmers deliberately leave plant mulch in the field after land clearing to cover the soil. This, farmers reported, helped to reduce weed growth and reduced the amount of time spent on weeding.

The case study team observed that to achieve effective weed control, about 30% of the farmers increased the number of herbicide applications from two, as recommended by the agricultural extension agents, to three. These farmers found this increase to be cost effective, as labour for weeding is hardly available, although there were also farmers who applied less than the recommended rates.

Soil quality

Farmers explained that leaving crop residue has reduced runoff and soil erosion and improved the soil condition. Fifteen out of 21 communities visited observed that the soil was moist, indicating that less runoff was taking place and more water was retained in the soil. They also indicated that the soil had changed in colour from red to dark red after three years of using crop residue.

The case study team observed improvements in soil moisture, and this was attributed to less runoff and more moisture retention due to mulch presence. However, changes in soil colour were not significant, contrary to what farmers indicated in both districts during community discussions.

Pests and diseases

In all communities visited, farmers mentioned that using cover crops without burning has increased the population of pests like leaf borers, millipedes, caterpillars and grasshoppers. The incidence is severe in the minor season. Farmers attributed this to the presence of unburned mulch. The case study team observed that the incidence of grasshoppers was localized and was not necessarily due to the presence of mulch. The only solution that farmers have is to use pesticides. Most farmers use a calendar spraying programme for controlling pests, although the extension officers claimed that all the communities visited have been trained in integrated pest management.

It was mentioned in Antwikrom, Kwaware, Johnsonkrom and Bethlehem communities of Sunyani District that frogs, rats, squirrels and sometimes snakes were seen on fallow fields with cover crops. The cover crop canopy created a good microclimate for them.

Issues with intercropping under conservation agriculture

Herbicides are used to build mulch to cultivate a variety of crops and are well integrated into different cropping systems in the study areas. They are used to clear the field and control weeds during production. Farmers carefully use post-emergence herbicides to prevent damage to food crops.

However, the same cannot be said for integrating cover crops into the farming system, especially in Sunyani District, where the use of cover crops dominates. The major system identified was a maize–mucuna intercrop.

Farmers in Johnsonkrom, Kwaware, and Antwikrom reported that their maize crop did not do well when mucuna was intercropped into their maize fields. Its vines entangled the maize and pulled some of the maize plants down. An estimated 30% yield loss was recorded from those fields. Competition for nutrients, light and space was also observed. It is therefore important to know when to plant mucuna to benefit from its nitrogen fixation, which can be about 150 kg N/ha, and its weed suppression (Loos et al. 2001).

Loos et al. (2001) observed that planting mucuna too early will result in competition but planting it late also reduces its chance to properly establish, especially in the minor season. To obtain a maximum benefit from mucuna–maize rotations, farmers plant late-maturing mucuna as relay intercropped at least 60 days after planting when they are doing their second weeding. Maize is normally harvested four weeks after planting the mucuna. This system, as most farmers explained, reduces the large amount of labour involved in planting mucuna alone. It also avoids a first weeding.

In some cases where weed infestation is high, farmers still have to do one weeding. After establishment, the mucuna survives the short dry period during July–August and later forms a thick biomass that peaks in mid-November. This biomass canopy then covers the soil until it starts to decompose in the dry season in December–January. Mucuna seeds are then harvested and stored for later use.

Unlike the late-maturing mucuna variety, planting the medium- to early-maturing mottled variety is done at the onset of the minor season (Loos et al. 2001). Clearing and at least one initial weeding may be necessary for successful establishment. Once established, the biomass covers the soil surface and dies back naturally with the onset of the dry season. This means that no other food crop can be planted on the land that has an improved mucuna fallow. After the improved fallow, farmers plant any other crop such as maize, yam, cassava or plantain.

In places where rice cultivation is significant, farmers have developed and adapted mucuna–rice rotations. Here, farmers cultivate rice in the major season and follow it with mucuna in the minor season to suppress weeds and improve the soil fertility.

Canavalia ensiformis did not attract the same attention as mucuna because it was less vigorous in growth and did not suppress weeds as well as mucuna. The less aggressive nature of canavalia made it an ideal cover crop to use in mixed-cropping systems.

Overall, incorporating cover crops into farming systems in Atwima District was not successful because of the following reasons:

- Farmers do not see cover crops as part of the traditional crops and these cover crops have no significant monetary benefits as compared with other traditional crops. Farmers expect to get immediate economic benefit from

> The case study team observed that incorporating mucuna into the local cropping systems by intercropping mucuna with plantain during the first season can be very economical. Such a system reduces the overall demand for labour, as it requires only spot weeding of mucuna vines at certain intervals.

any crop that they plant. Therefore, planting a cover crop as a minor-season crop without getting any economic return was difficult for farmers to accept. Farmers do not consume mucuna and canavalia seeds, and the promoters of cover crops failed to promote use of cover crop seeds.

- Farmers' continual use of land throughout the year and the mixed-cropping system do not favour incorporating mucuna. It cannot be used as an intercrop and it will entangle the main crop and cause lodging in some cases. Hence, mucuna was planted as a relay intercrop a month before harvesting the main crop so that it could establish for at least one season. Where farmers are continuously planting in both seasons, there is no short-season fallow during which mucuna can establish. There has been no conscious effort to promote cover cropping in Atwima District.
- Farmers indicated that *Canavalia* sp. is more susceptible to aphids, which infest the pods without any significant effects on the biomass; therefore, it is more suitable under the mixed-cropping system of farming.

Biomass management

Canavalia and mucuna are leguminous cover crops that grow aggressively and produce large quantities of biomass.. After they are well established, they produce adequate biomass that provides soil cover and suppresses weeds. The biomass is left on the field until the next planting season.

Farmers protect their fields from two main threats: bush fires and overgrazing by stray animals.

To effectively manage their biomass, some farmers create firebelts around their fields. Sanctions to combat bushfires were in place in 15 communities interviewed, as part of the bylaws, such as:

- no fire-bearing objects such as matches or cigarettes lighters carried to farms during the dry season (December to April)
- no hunting for game
- no use of fire for palm wine tapping in the dry season
- no smoking in bushy areas

Everyone is urged to be alert for fire and report any outbreak. Fire volunteers are to be consulted before burning in the dry season. The following sanctions are to be enforced:

- Culprits are fined a penalty of GHC[1] 200,000–700,000 or pay the cost of goods damaged.
- Culprits are sent to the law court for prosecution.

Sheep and goats normally cause massive destruction of farms by grazing. Farmers in 16 communities mentioned that sprinkling crops with animal droppings could check this. The unit committee, which is part of the local government structure, has bylaws to control livestock grazing. A monetary fine is imposed on offenders, which serves as a deterrent to others.

1 GHC – Ghana cedi, valued at 9100 cedis to USD 1

Livestock owners are fined a huge sum of money (determined by local opinion leaders or unit committee members of district assembly) when they fail to contain their animals and allow them to destroy farms. Any member who apprehends any stray animal is given a minimum amount of GHC 50,000, and this amount is charged to the animal owner. In addition to the fined imposed by the committee, the offender must also pay for crop damage.

However, these types of sanctions are effective in only seven communities, especially in Atwima District. The unit committee in these communities makes sure that offenders are fined and those who apprehend the animals are given their fee. The same situation is not found in other communities, as the unit committee members are not too keen on livestock issues.

Socio-economic impact

Labour

Positive effects of the promoted conservation agriculture practices on labour use have been observed and reported through on-farm trials and farmer group meetings.

In a comparative analysis of conservation agriculture practices with slash-and-burn systems, a labour reduction of at least 30% (SFSP 2002) was achieved by practising conservation agriculture technologies (table 8). The reduction, according to SFSP's impact assessment report of 2002, was mainly due to less labour required for land preparation and weeding operations.

Farmers plant cover crops in a previous season so that they can achieve their objectives of suppressing weeds, reducing the weed seedbank and producing adequate biomass and mulch cover for the subsequent season. Relay intercropping of these cover crops into the farming systems enabled farmers to plant cover crops during the second weeding of maize, minimizing the labour.

In focused group interviews with data collected from group members, farmers broke down different operations and labour inputs as presented in table 9.

Farmers practising minimum tillage reduced labour (work hours) by at least 42%. A higher labour use was recorded for planting on the minimum-tillage fields due

Table 8. Labour reduction using conservation agriculture practices

Treatment	Cases (no.)	Labour/operation (work hours)	Labour returns per work hours (GHC)	Total labour work hours
Minimum tillage and direct planting	10	41	83,523	22
Control plot (slash-and-burn)	10	32	49,778	35
Percentage change		22%	40%	37%

Source: Field survey 2005

GHC – Ghana cedi, valued at GHC 9100 to USD 1

Table 9. Labour reduction using minimum tillage

Activities/acre	Minimum tillage (work days)	Slash-and-burn (work days)
Initial land clearing	15	15
Burning	0	1
Uprooting grass and destumping	0	20
Gathering residues for second burning	0	10
Spraying pre-emergence herbicide	2	0
Planting	15	2
First weeding	0	15
Second weeding	0	15
Spraying post-emergence herbicide	1	0
Harvesting	15	5
Total	48	83

Source: Field survey 2005 (average of 15 communities)

to the presence of mulch. Farmers indicated that it is much more difficult to plant manually (using dibbler or stick or machete) in rows through the mulch than to plant in the plain burned field. No manual weeding was done on the minimum-tillage field because herbicides had been applied.

The most tedious and time-consuming activities under the slash-and-burn system were uprooting grass and destumping for the second burning before planting. Mostly women and sometimes children were engaged in this type of activity, leaving them little time for household activities.

Farmers are also able to take advantage of the early rains for planting, as they do not need much labour to prepare their fields. Nor do they need much weeding. As it comes when most migrant labourers have returned to the north to start their farm operations, the labour shortage can be critical at weeding times.

Demand for labour increased during harvesting due to high yields achieved with minimum tillage. This also affected labour for carting or transporting, which women usually do.

Impact on women and children

Increased yields results in increasing the number of work days needed to harvest and cart, making harvesting a costly affair. Bumper harvests mean more work. Carting is normally done by tractor and sometimes by women. Planting in rows, with 40-cm spacing within rows, also requires a lot of labour compared with planting without any recommended pattern. It was mentioned in farmer group meetings that it can be dangerous and difficult to plant on land covered with a lot of mulch. Hidden tree stumps and piercing sticks have occasionally caused injury. But planting without a machine like a planter makes the process more tedious.

Through group discussions, it became clear that the most important consideration for using conservation agriculture was not only the reduction in hours spent but also less stress and drudgery associated with the practices. In a female-headed household, a reduction of even one working day gives time to handle off-farm activities such as trading for additional income.

Inputs: availability, accessibility and affordability

Equipment

Several types of machines and equipment are currently available and in use for farmers in conservation tillage systems.

- **Jab planters** are scarce in both districts although a few are believed to have been introduced by researchers for trial purposes. The case study team later discovered about 100 of them, manufactured by the Agricultural Engineering Department of the University of Science and Technology, Kumasi, with funds from FAO. They have been lying on hand for years and have not yet been tested in the field. The quoted price was USD 20, and farmers reject it as expensive. Small-scale farmers cannot afford this price unless they purchase jab planters as a group. The dibbler or planting stick and the machete remain the main planting tools.
- **Knapsack sprayer:** It is not uncommon to find farmers renting knapsack sprayers from other farmers because they do not own one. The price of a knapsack sprayer is about USD 50. The team observed two main types of renting or hiring arrangements in the study areas. In the first arrangement, farmers hire the equipment from the owner and use it to spray their fields. The farmer who is renting is expected to clean the machine and make full payment after using it. In the second arrangement, the farmer hires the services of a 'spraying gang' that owns and maintains the equipment. The spraying gang sprays the agrochemicals. The gang receives periodic training from the Ministry of Food and Agriculture and major agro-input sellers in Kumasi. The former arrangement is common in Sunyani District, the latter in Atwima District. This influences timeliness of operations and to a lesser extent, reduces cost of operations. In spite of these arrangements, the amount of equipment available is small and many farmers do not have access to it.

Agricultural extension officers mentioned other equipment, such as hand-held slashers, but farmers said that they have not seen nor heard of it. The study team did not see this type of equipment in any of the communities visited.

Cover crop seeds

Farmers received free canavalia and mucuna seeds and technical advice from the projects that promoted the concept of conservation agriculture in the study areas. Cover crop seeds were supplied through MOFA in conservation agriculture-related projects. Farmers were given 3 kg of cover crop seeds free of charge as an incentive.

They were expected to multiply this quantity during the experimental phase to cover others areas in the following season. Farmers who harvested more seeds shared with other farmers within their group. These other farmers contributed labour during seed harvesting.

Today, cover crop seeds are not sold in agrochemical shops, making it difficult for farmers who would like to buy them.

> The study team observed that to get more seeds to distribute to farmers in other communities, MOFA purchased cover crop seeds from some contact farmers. This created an artificial market for cover crop seeds and induced the adoption of cover crops, because most farmers planted the cover crop with the view of selling seeds to MOFA. When the project closed, MOFA stopped purchasing the seeds from the farmers. This resulted in a decline in adoption rate as some farmers abandoned cover crop technology in their fields.

Agro-inputs

There has been an increasing general trend in importing and using pesticides, indicating an improvement in availability. However, these agro-inputs are concentrated mainly in Accra and Kumasi. According to Ekboir et al. (2002), knowledge of the agro-input market is strongly correlated with size of farm and agrochemical use as the wealthier farmers are able to purchase inputs, especially glyphosate, which is critically needed to prepare land and control weeds.

The herbicides readily available on the market are glyphosates. The most common are Round-Up, Chemosate, Helosate, and Roundo; others are Atrazine and Kaliherb.

According to agro-input dealers, patronage is high. The price of a litre of herbicide is GHC 45,000–55,000, depending on the product. Farmers indicated that it was too expensive and they tended to apply less than the recommended rate to be able to cover a larger area. This confirms findings reported by Ekboir et al. (2002) that a large portion of farmers (70%) use less glyphosate than recommended.

> Sefa and Jane Agro Chemical Limited is one of the major agro-input shops in Kumasi. The owner is a distributor of many types of pesticides. Major sales are through projects. Currently, the distributor works with the Food Crops Development Project (financed by the African Development Bank) to supply inputs to project clients. The project submits a request to the shop to provide a certain quantity of inputs, for which the farmer pays later into a bank account created for this purpose. Therefore, farmers use the project as collateral to gain access inputs for production. Inputs supplied range from pesticides and fertilizer to equipment and tools like knapsack sprayers, cutlasses and hoes.
>
> As back-up support, the distributor organizes training for the project farmers from time to time. This is done for both conservation agriculture and non-conservation agriculture farmers.
>
> Besides this arrangement with the project, the dealer also sells directly to individual farmers on a cash basis, and bulk purchases attract discount.

The study team observed that pesticides are most often adulterated because of the high price and farmers' lack of knowledge about them. Wayside agrochemical dealers take advantage of farmer ignorance to sell adulterated or fake products that are not environmentally friendly.

The prices of selected products are presented in table 10. Farmers mentioned that prices kept increasing.

Table 10. Cost of agrochemicals in Kumasi, June 2005

Type of chemicals	Active ingredient	Price (in cedis)
Herbicides		
Round-Up	Glyphosate	45,000–55000/litre
Roundo	Glyphosate	55,000/litre
Kaliherb	Glyphosate	45,000/litre
Atrazine	Atrazine	45,000/litre
Pesticides		
Thionex (for cocoa)		60,000–65,000/litre
Kuzitrine (vegetables)		45,000
Cyperphos (vegetables)		45,000 15/250 ml
Fury P (vegetables)		45,000 15/250 ml
Fungicides		
Topsin-M		40,000/500 g
Funguran-OH		55,000/kg
Merpan 50 WP		55,000/kg
Sharit F 1.5 WP		110,000/kg

Source: Field survey 2005

When prices of different years were compared, it became clear that prices across the country had increased, confirming farmers' claims. Round-Up, for example, increased by 11% from 2002 to 2003 (table 11).

Table 11. National average input prices (in cedis)

Input	2001	2002	2003	Change 2002–03 (%)	2004	Change 2003–04 (%)
Urea	126,860	138,440	142,200	2.7	189,440	33.2
15-15-15 (50 kg)	108,400	123,580	149,480	21.0	188,650	26.2
Sulphate of ammonia	90,940	101,650	109,860	8.1	142,220	29.7
Round-Up	—	59,250	60,740	2.5	70,600	16.2
Karate	—	70,780	78,770	11.3	79,100	0.4
Actellic	—	91,670	107,880	17.7	*50,000	–0.5
Cutlass	19,490	22,200	25,550	15.1	27,120	6.1
Hoe	5,890	8,540	11,180	30.9	12,380	10.7
Jute sac	5,600	6,390	8,040	25.8	7,540	–6.2

Source: SRID, MOFA

Gross margin analysis

The team analysed the benefits and costs of some conservation agriculture practices. It concluded that minimum tillage proved superior to slash-and-burn in maize yield achieved, as presented in table 12. Maize yield of 3 t/ha without fertilizer was achieved with conservation agriculture compared with 1.2 t/ha from slash-and-burn. This represents an increase in yield that is more than double.

Table 12. Gross margin analysis of maize production

	Minimum tillage			Slash-and-burn		
Item	Quantity (t/ha)	Unit price ('000 GHC)	Amount ('000 GHC)	Quantity (t/ha)	Unit price ('000 GHC)	Amount ('000 GHC)
Costs						
Herbicide (litres)	2.0	120	240	—	—	—
Labour (work days)	48.0	15	720	83.0	15	1245
Hiring of knapsack	1.0	20	20	—	—	—
Total cost			*980*			*1245*
Revenue						
Yield (kg)	1.2	15	1800	0.5	15	750
1.2 Gross margin			820			–495

USD 1 = cedis (GHC) 8700 in February 2005

These results were consistent with those obtained by Adjei et al. (2003) (table 13). The team came to the following conclusions:

- In comparison to slash-and-burn, the use of human labour decreased in conservation agriculture by 24% due to a reduction in labour related to slashing grass and controlling weeds in slash-and-burn systems (tables 12 and 13).
- The net return per hectare was 145% higher in conservation agriculture than in slash-and-burn, due to better productivity of maize.

In all cases, yields and financial returns increased with conservation agriculture practices.

8 Discussion

The projects that introduced conservation agriculture practices in the study areas made use of participatory approaches when the technology was being introduced and promoted. The projects also made use of MOFA extension officers to ensure maximum coverage of communities and avoid building structures parallel to those of the MOFA extension system. Emphasis was placed on demonstrations and field experimentation of proposed technologies. However, the link between farmers, extension and researchers during field experimentation was not that visible.

Table 13. Cost–benefit analysis of maize production under two tillage systems (cedis/ha)

Criteria	Unit	Tillage system	
		Slash-and-burn	No-till and direct planting
Land rent	cedi	125,000	125,000
Ploughing charges	cedi	0	0
Seed	quantity (kg)	24	25
	value (cedi)	85,000	92,250
Fertilizer	qty (50-kg bags)	4	5
	value (cedi)	478,333	628,438
Herbicide	qty (litres)	0	4.08
	value (cedi)	0	234,375
Labour	work days	90	69 –(23.61)
	value (cedi)	1,222,395	814,063
Machine shelling costs	cedi	113,333	120,938
Transport costs	cedi	149,583	157,500
Variable costs	cedi	2,048,643	2,047,563
Total costs	cedi	2,173,643	2,172,563
	%		(–0.05)
Yields	tonnes	2.18	2.7
Labout saved	%		(+24.14)
Quantity sold	%	80–90	80–90
Price	cedi/t	1,200,000	1,200,000
Gross return	cedi/t	2,610,000	3,240,000
Net return	cedi/t	436,358	1,067,438
	%		(+144.62)

Source: Adapted from Adjei et al. (2003)

9 communities in Sunyani, 12 communities in Nkoranza

Farmer experimentation was useful to introduce and promote conservation agriculture practices, especially the use of plant mulch and cover crops.

Introducing and promoting herbicides for minimum-tillage trials was spearheaded by Monsanto's representatives and accredited distributors. Funds from Monsanto were used to set up roadside demonstrations and to train MOFA extension officers and farmers.

The intensity of efforts in terms of activities in promoting conservation agriculture reduced drastically after the projects ended. One of the main reasons cited for this development is that the central government has limited funds for extension activities. Policymakers have not been convinced of the benefits of conservation agriculture and its potential to improve rural livelihoods. Although some effort has gone into Brong Ahafo and Ashanti Regions, activities have largely remained as pilot interventions, without widespread adoption that would show the benefits and potential of conservation agriculture in different ecological and sociocultural environments. The scope of coverage of the projects related to conservation agriculture was in most cases predefined by the donors. These projects thus were more or less restricted to a particular geographical area.

Individual projects had other objectives to accomplish unrelated to conservation agriculture, and they tended to treat it as an add-on instead of a mainstream objective. Some projects were primarily interested in having a large number of farmers participate in demonstrations, to meet requirements when reporting to their funding agencies. The projects also largely worked with contact farmer groups and if similar groups were not formed in other communities, promotion of proven technologies was limited.

Thus MOFA capacity, built by the conservation agriculture projects, remains largely untapped. No specific MOFA unit can be identified that is actively promoting conservation agriculture in Ghana.

Use of herbicides is high and increasing. Since labour is largely unavailable and expensive in most communities, farmers find using herbicide cost effective and convenient for preparing land and weeding. But as herbicides are neither readily available nor affordable, the farmers apply them at less than recommended rates.

Farmers still do not have adequate knowledge about using herbicides. Also, adulterated agrochemicals do not perform with the expected efficacy, making farmers doubtful about herbicides in general. Most farmers are illiterate and cannot read the labels. They must therefore rely on others regarding application rates and frequency of use.

The presence of spraying gangs in some communities has helped ease the problem of farmers finding access to a knapsack sprayer for applying the chemicals. However, using the stick and cutlass for planting still remains a major bottleneck. The conservation agriculture projects did not actively promote appropriate equipment for planting, especially through the mulch. Planting equipment like the jab planter was not available locally. Attempts to manufacture jab planters locally were not successful due to problems in calibrating them. Not much research has gone into developing equipment for smallholder planting.

Conservation agriculture practices have had a positive effect on yield and have proved superior to the traditional slash-and-burn method of farming. However, farmers have also reported yield reduction on soils with hardpan. Therefore, hardpan needs to be broken where it exists. At present, chisel ploughs or rippers are not readily available in the communities, except in a few difficult-to-access agricultural machinery stations.

There was little evidence to show soil fertility improved or erosion controlled. These were qualitatively assessed using change in colour although the assessment was rather unconvincing, and the study team observed no visible improvements during its field visits.

9 Gaps and challenges

Conservation agriculture practices have been promoted by a number of organizations in different areas of the country, either as a pilot or as full-scale projects. But a number of issues still need to be addressed before the full benefits of conservation agriculture can be realized in Ghana.

The main obstacles can be categorized as follows:

- unavailability of cover crop seeds
- unavailability of appropriate equipment and tools
- limited promotion of conservation agriculture
- little or no institutional support

Availability of cover crop seeds

One of the main reasons for a higher number of farmers using herbicides was the absence of appropriate cover crops that could be integrated into their farming system to control weeds. Only a few cover crop types or species are available, mainly *Mucuna*, *Canavalia* and *Pueraria*. The seeds are scarce and difficult to find. They are not sold in the agro-input shops. The conservation agriculture projects that introduced cover crop seeds were limited in scope; hence they concentrated on just a few communities. As a result using cover crops to build plant mulch for a permanent soil cover and to control weeds is not as widespread as using herbicides to build a permanent soil cover.

The cover crops available are not multipurpose, and because of this, farmers have little interest in cultivating them. Farmers in general want to eat or sell whatever they plant in their fields. Showing farm families how to use mucuna seeds for food and feed could help overcome this constraint.

Appropriate conservation agriculture tools and equipment

Equipment and tools for preparing land, planting and weeding under conservation agriculture systems do not exist in the country, except for a few used experimentally. Planting through mulch still remains the greatest challenge to promoting conservation agriculture in Ghana. Farmers spend too much time trying to plant through the mulch using the dibbler (stick) or the machete (cutlass) compared with the traditional slash-and-burn system, where planting is done on bare soil. It becomes even more difficult when the mulch quantity is high and planting is done in lines.

Jab planters introduced in early 2000 have not been field tested or promoted. According to a researcher and extension officer in Sunyani District, jab planters are not likely to be found suitable for clay soils, especially when these soils are wet, as after irrigation or rains. Under these conditions they get clogged and do not longer operate efficiently. Neither farmers nor extension officers know much about how to use a jab planter.

Presently, the most important implement available for medium- and large-scale farmers is the tractor-mounted disc plough. It is used extensively throughout the country, destroying the soil structure and increasing its risk of erosion. If conservation agriculture is to be used across a wider area, and by medium- to large-scale farmers, appropriate machinery, tools and implements are needed at affordable prices.

Limited promotion

Finding resources for promoting conservation agriculture is a huge problem in Ghana. Promoting conservation agriculture has been limited to project pilot districts and little upscaling has been done. The knowledge and experience built by the projects remain largely untapped and unused. That the sustainability of these efforts is not assured leaves much to be desired. Hence, there are pockets of success in Ghana, mainly Brong Ahafo and Ashanti Regions, but the same cannot be said for the whole country. How to scale up success stories from these pilot activities remains a dream that has is yet to be realized.

Institutional support

Policymakers are yet to be convinced that conservation agriculture merits support because of its numerous benefits. Data on its adoption scarcely exist and what data are available are neither coherent nor considered accurate. Few success stories in the country have been tested in different sociocultural, ecological and biophysical conditions for wider acceptance. The evidence that exists has not been well packaged or presented to policymakers for support, except a presentation of a joint GTZ–International Center for Development-Oriented Research in Agriculture (ICRA) field study in 2003 that brought major conservation agriculture practitioners and policymakers together. Conservation agriculture is not generally among the major agriculture issues championed by the Ministry of Food and Agriculture because the extension officers in the field have not managed to communicate the potential of conservation agriculture to their superiors.

Due to budget constraints, the Land and Water Management Unit, created by LWMP to oversee the implementation of conservation agriculture-related activities, is scarcely functioning since the project closed.

Knowledge of conservation agriculture and experience with it exist, especially within the Ministry of Food and Agriculture but they are not widely used to promote it, as little support for such activities is forthcoming from the ministry.

Pests and diseases

Farmers give conflicting reports regarding the build-up of pests and diseases resulting from mulch build up, but the topic has not been well researched.

Some farmers claimed that the mulch increases pest build-up and encourages crows and rodents to eat planted seeds and seedlings. Others maintained that the mulch presence has actually reduced seed removal. Some farmers who planted cover crops claimed that the crop canopy created a microclimate in which snakes and rodents hid.

10 Conclusion and recommendations

After analysing discussions held with key informants, farmer groups, extension officers and former project staff, the team made the following observations influencing farmers in adopting and using conservation agriculture:

- Communities where conservation agriculture has not been actively promoted already practise some form of conservation agriculture, locally known as proka.
- Cover crop seeds are not available. Seed availability is a problem for new adopters. Farmers now find it difficult to acquire seeds. While agro-inputs are available in the big cities they are not readily available in farming communities. Adulteration of chemicals is also a major problem.
- Using cover crops in improved fallows still requires initial land clearing, additional labour for spreading the mulch and planting through the residue, which is cumbersome.
- Farmers complained about the scarcity and high cost of herbicides and other agro-inputs during the planting season.
- Produce prices are low compared with rising input costs.
- Planting by hand, using stick or machete on fields with mulch is a cumbersome, difficult task.

Based on the findings of this case study, the team recommends the following for further discussion and consideration:

- Greater effort should go into introducing multipurpose cover crops to control weed populations, stimulate improved soil fertility, and enhance yields while diversifying crop production. This will reduce heavy dependence on the use of herbicides.
- Introducing and promoting appropriate conservation agriculture equipment and implements while ensuring proper support services will greatly improve labour productivity and enhance the adoption of conservation agriculture.
- Donor-led projects are still needed to build a critical number of conservation agriculture successes and to convince the government of the benefits of conservation agriculture and its potential to resolve food security problems and guarantee a sustainable source of livelihood for rural farmers.
- The knowledge and experience acquired over the past few years should be harnessed and used.
- If policymakers are to take up conservation agriculture, a communication or lobby group is needed to properly package its success stories and share them regularly with the policymakers.

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Appendix 1 Field interview synthesis

Key informant: Asare Baffour, Sunyani District
Compiled by Benjamin A. Dartey, Genevieve D. Dela, Emmanuel Asare

The Sedentary Farming Systems Project (SFSP) pioneered the development of ecologically and economically sound alternative farming systems by introducing *Mucuna pruriens* and other green manure crops. *Mucuna pruriens* was initially introduced as a relay intercrop with maize and later developed into a minor-season short fallow system. Currently in Sunyani District, *M. pruriens* is incorporated into two systems: a late-planted relay intercrop system using late-maturing varieties and a minor season fallow using a medium-maturing variety.

Cover crops have long been a topic of research in Ghana. However, until recently farmers had not adopted cover crop systems on a large scale despite their agronomic potential.

The Brong Ahafo Region of Ghana is considered one of the food baskets of the nation. Reduced fallow periods due to increasing population have led to a decline in soil fertility and hence to reduced agricultural productivity. SFSP offered a number of technologies to farmers. Out of these, mucuna as a cover crop and green manure received the most attention. The system contrasts with the predominant shifting cultivation and bush fallow systems.

Presently this technology is being introduced with a community-based approach, with participatory technology development used as a major tool. As a general rule, farmers participating in the project do not receive incentives for implementing and maintaining their demonstration plots other than seeds or planting materials that are not easily available elsewhere.

Mucuna cropping systems in Sunyani District

Mucuna cropping systems in Sunyani District are as follows:

Relay intercrop of maize with late-maturing mucuna varieties (black seeds)

Mucuna is sown in between maize, after it tassels or later, with a recommended planting density of 0.3 m x 0.9 m and two seeds per hill. The ideal planting period is in June, when average rainfall is highest for the year. Again, this is the time when farmers are not occupied with many other farming activities. But if the maize is planted late and tasselling occurs after July, it may be too late to plant mucuna since as the dry period between the middle and the end of July will affect its establishment. Late-maturing mucuna should be planted after the last maize weeding. This will drastically reduced weeding and any additional workload except for planting and harvesting of seeds for mucuna cultivation. Planting mucuna as an intercrop resulted in its competing strongly with maize. Substantial time and efforts were needed to regularly remove the creeping vines from the maize stalks.

However, plots planted with mucuna recorded signs of soil improvement vis-à-vis the control plots that were left to fallow. Volunteer cocoyam and local fodder shrubs performed better on the mucuna plots than on the control plots. Also, weeds on the mucuna plot were drastically reduced, hence saving time and being cost effective as compared with fierce competition from *Chromolaena odorata* and other weeds like *Imperata cylindrica* on the control plots, which required two to three weedings. Additionally, maize yields from mucuna fields were 50% higher than from control fields left to fallow.

Minor-season mucuna fallow with medium-maturing mucuna varieties (mottled type) as a sole crop

In this system, mucuna is planted as a minor-season fallow in a pure stand. The total workload, however, is envisaged to be higher, the labour needed is likely to compete with other important farming activities, and the total biomass production may be lower than when the mucuna is planted earlier.

Mucuna under plantain

Incorporating mucuna into the local cropping system, where maize is intercropped with plantain during the first season, can be economical because the overall demand for labour is reduced, as it requires only spot weeding of mucuna vines at certain intervals. It might also control nematode infestation in plantain.

Adoption

The high adoption rate of mucuna as a cover crop resulted in huge demand for seeds. Seeds had to be purchased from other farmers in addition to those from the Crop Research Institute. At the Atebubu Agricultural Station, black mucuna seeds, known as 'exotic', were purchased as well.

The extent of adoption was significant; no other technology received such a response. Applying animal manure to maize resulted in a yield increase of more than 100% over a control field. Nevertheless, no farmer continued with this technology, presumably because it was more labour intensive and the price for the produce was relatively low.

Farmers continue to apply animal manure to plantain in spot application and to tomato (high-value crop), although to a lesser extent; they are restricted by the lack of available animal manure. The use of *Canavalia ensiformis* did not attract the same attention as mucuna, although it has been recommended as a cover crop with perennial crops such as plantain, or with crops like yam that cannot be combined with mucuna. The weed-suppressing effect of mucuna is greatly appreciated by farmers and is much greater than with canavalia.

The motivation for farmers to adopt cover cropping with mucuna is twofold: to improve soil fertility and to suppress weeds. However, some farmers adopted with the aim of getting monetary benefit by selling mucuna seeds. Although farmers remarked positively about mucuna, they also mentioned the additional workload in planting and harvesting and problems of splitting pods and bush fires.

Setting up fire strips is a general recommendation, and also cultivating a minor-season crop around the mucuna plots, but this did not prove successful. Many farmers did not set up such strips. In some cases where there were well-established fire strips, fire broke out from the centre of the field, indicating that the fire was set intentionally. This can be attributed to indiscriminate hunting activities during the dry seasons.

Land tenure systems

Sharecropping

The sharecropping system of acquiring land favours adopting cover cropping and using herbicides to control weeds. Landowners provide the farmers with some mucuna seeds for their farms. Two common sharecropping systems are *abunu* and *abusa*.

Abunu

The *abunu* system is used for acquiring land to plant or replant cocoa. An initial cash sum is paid to the landowner, which would be at least GHC 300,000.00 (USD 50) up to GHC 600,000.00 (USD 100), depending on the quality of the land. This will be for an area of land that a farmer can clear and farm. In the first few years, maize, cassava, cocoyam and plantain will bear, planted as an intercrop with cocoa. Plantain acts as a shade tree for the cocoa. The landowner pays for the cocoa planting material, be it seeds or seedlings. Depending on the soil fertility, the cocoa will start fruiting in three to six years. During the first years of the food cropping the farmer takes all proceeds from the crops. Once the cocoa is established the land is divided. The landowner takes 50% of the land area and the farmer takes the other half.

The land is then legitimately the farmer's, as long as land use is maintained. If the farmer manages the land well and replants cocoa trees as they lose their vigour the farmer and children can keep and farm the land for even longer than 100 years. If land use changes the original owner can reclaim the land.

Abusa

The *abusa* agreement is used for food crops such as maize, cassava, cocoyam and plantain. In this instance the landowner claims one-third of the crop yield each year the land is cropped and the farmer takes two-thirds. After the land is exhausted and left to fallow it goes back to the owner.

Hired or rented land

Hired land requires paying a cash sum. Farmers normally pay GHC 100,000 for an acre of land for just one year or sometimes two years. Especially if in need of cash, the landowner may rent the land out even for four or five years. Rented land is used to produce crops like rice, vegetables, maize, cassava, cocoyam, or a plantain intercrop.

Some landowners rent out land they consider unproductive. If they rent it out for a long period then see that it begins to produce under no-tillage practices—they ask for the land back!

This type of land ownership has not in any way affected introducing cover cropping.

Family land

Land that was obtained by the farmer's parents or grandparents along matrilineal lines by clearing virgin forest or through abono agreement is regarded as family land held in trust for the farmer's children. The land may be planted with cash or plantation crops, vegetables or as a food crop intercrop. The farmer takes all the proceeds from the farm in this case.

This mode of land acquisition has encouraged cover cropping and no-tillage or minimum-tillage techniques.

Individual land

It is possible to transfer land from parents to children. This is accomplished with the approval of the chief while the parents are still alive, and witnesses affirm that the transfer has taken place. It is possible to purchase land outright. In both cases the control is in the hand of the sole owner. The land is often planted with plantation crops.

Appendix 2 Communities visited

District/Community	Farmers met (no.)		Conservation agriculture status
	Male	Female	
Atwima District			
Abuakwa	5	2	promoted
Adeemmra	4	3	promoted
Aferi	4	4	non-conservation agriculture
Bedabour	6	4	promoted
Koforidua	5	3	spontaneous adoption
Kokoben	4	2	promoted
Manhyia	4	3	promoted
Mmadaa	10	5	promoted
Mpasatia	6	4	promoted
Nkrumah	8	4	non-conservation agriculture
Nyinahini	5	1	promoted
Sunyani District			
Antwikrom	5	2	promoted
Bethlehem	7	0	promoted
Chiraa	10	3	promoted
Johnsonkrom	5	5	promoted
Kobedi	4	3	spontaneous adoption
Kwaware	4	2	promoted
Nsoatre	8	5	promoted
Odumasi	9	4	non-conservation agriculture
Tanom	6	4	promoted
Timber Nkwanta	6	5	non-conservation agriculture
Total no. farmers	125	68	

Appendix 3 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.

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 adapted 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.

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