



# Zambia

## Conservation agriculture in Zambia: a case study of Southern Province

*Frédéric Baudron, Herbert M. Mwanza, Bernard Triomphe, Martin Bwalya*

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

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

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

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

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

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

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

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CONSERVATION AGRICULTURE IN AFRICA



# **Conservation agriculture in Zambia: a case study of Southern Province**

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# Contents

Abbreviations .....	vii
Preface .....	viii
Acknowledgements .....	ix
Case study project background and method .....	x
1 Introduction.....	1
2 Biophysical, socio-economic and institutional environment .....	2
Climate.....	2
Socio-economic and sociocultural characteristic of families and communities.....	3
Farming systems.....	3
Infrastructure, market and communication .....	4
3 Description of conservation farming technologies .....	4
Planting basins .....	5
Ripping .....	6
4 History of work related to conservation farming .....	7
From independence to the 1990s: expansion to crisis (1964–1991).....	7
Spontaneous responses of smallholders.....	7
Genesis of conservation farming in Zambia.....	8
Government and donor support (1999–2003).....	9
5 An overview of the conservation farming diffusion process .....	10
6 Conservation agriculture adaptation .....	11
Muyamba pits .....	11
Fertility trenches.....	12
Hand-drawn equipment.....	12
7 Impact of conservation farming .....	12
Planting basins .....	13
Ripping .....	14
8 Adoption of conservation farming .....	14
Planting basins .....	14
Magoye ripper.....	15
9 Present gaps and challenges: ‘burning issues’ .....	15
Conservation farming and labour constraints .....	15
Peak labour and dry land preparation .....	17
Residue and biomass management.....	17
Crop rotation.....	18
Subsidies and adoption .....	19
Lack of tangible data demonstrating conservation farming as economically viable ..	19
Precision.....	20

10	Discussion: the way forward.....	20
	Using herbicides and cover crops.....	20
	Facilitating dry-season land preparation.....	22
	Increased reliance on animal draught power ('oxenization') .....	23
	Increasing flexibility in approach to conservation farming development and diffusion.....	23
11	Concluding remarks.....	24
	References .....	25
	Appendix 1 Fast-track technologies.....	26
	Appendix 2 Summary of conservation farming tillage inputs and yields, based on a plot of 1 lima.....	27
	Appendix 3 Reference framework .....	28

### **Figures**

Figure A	Entry points and four hypothetical pathways towards adopting conservation agriculture.....	xi
Figure 1	Agroecological zones of Zambia.....	1
Figure 2	Comparison of maize cultivation under conventional farming and under conservation farming.....	6
Figure 3	Timing in land preparation in different maize systems .....	13
Figure 4	Components of conservation farming as recommended and related constraints .....	16

### **Tables**

Table A	Milestones of the case study project on conservation agriculture.....	xiv
Table B	Key characteristics of case studies selected in Africa .....	vii
Table 1	Mean monthly temperatures (°C).....	2
Table 2	Major stakeholders and component of conservation farming diffusion in Zambia.....	11
Table 3	Schedule for a continuous weeding regime.....	13
Table 4	Labour required for preparing land and weeding cotton in conservation vs conventional farming (1 day = 8 hours).....	16
Table 5	Smallholders using animal draught power and effect on their farming systems.....	23

## Abbreviations

ACT	African Conservation Tillage Network
AIDS	acquired immunodeficiency syndrome
ASP	Agriculture Support Programme
CA	conservation agriculture
CFU	Conservation Farming Unit
CIRAD	Centre International de Recherche Agronomique pour le Développement
CLUSA	Cooperative League of the USA
FAO	Food and Agriculture Organization of the United Nations
GART	Golden Valley Agricultural Research Trust
HIV	human immunodeficiency virus
ICRAF	World Agroforestry Centre
IMAG	Institute of Agricultural and Environment Engineering
lima	land unit that equals 0.25 ha
LM&CF	Land Management and Conservation Farming
MACO	Ministry of Agriculture and Cooperatives
NGO	non-governmental organization
Norad	Norwegian Agency for Development Cooperation
RELMA	Regional Land Management Unit
SCAFE	Soil Conservation and Agroforestry Extension
Sida	Swedish International Development Cooperation Agency
UNDP	United Nations Development Programme
SLM	sustainable land management
WFP	World Food Programme
ZARI	Zambia Agricultural Research Institute
ZNFU	Zambia National Farmers Union



## 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 Zambia. 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:<sup>1</sup>

*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.

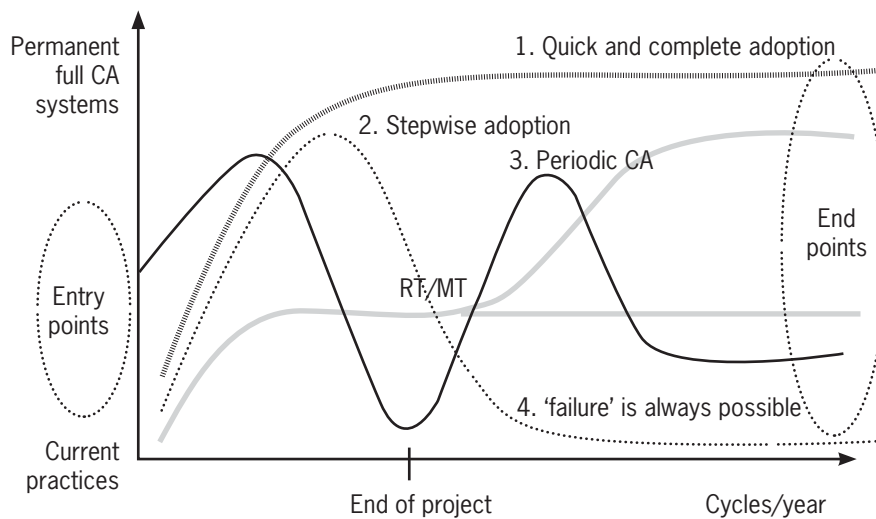



Figure A. Entry points and four hypothetical pathways towards adopting conservation agriculture:

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<sup>2</sup> and experiences and for characterizing in a holistic way

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

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

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

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

### **What does a case study entail?**

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

### **Majors phases of the case study project**

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

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

## **Key methodological choices**

### **Case study framework**

The framework was developed in several stages. It integrated a series of previously identified issues, such as those developed under the auspices of programmes such as the Direct Seeding, Mulching and Conservation Agriculture Global Partnership programme<sup>3</sup> of the Global Forum for Agricultural Research (GFAR), WOCAT<sup>4</sup> and Sustainet.<sup>5</sup> 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

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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>

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<sup>6</sup>
- 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<sup>7</sup>

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

#### **How case studies were developed**

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

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

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

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

<sup>6</sup> 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.

<sup>7</sup> 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.



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 (years)	Adoption status	Supportive project	Team leader
<b>Kenya</b>					
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
<b>Tanzania</b>					
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
<b>Ghana</b>					
Brong Ahafo, Ashanti	Rainforest transition / smallholders, purely manual agriculture	> 10–15 years	Significant but stagnant	FAO-RAFA / RELIMA	Philip Boahen, consultant
<b>Uganda</b>					
Pallisa, Mbarara, Mbale	Humid to sub-humid / smallholders	3–5 years	Incipient	FAO-TCP	Paul Nyende, consultant
<b>Zambia</b>					
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; FAORAF – FAO Regional Office for Africa; RECODA – Research, Community and Organizational Development Associates; RELIMA – 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<sup>8</sup> 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.

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<sup>8</sup> 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 Zambia. 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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# 1 Introduction

Famous worldwide as a copper-producing country, Zambia is also increasingly known as a success story for conservation agriculture, with smallholders adopting it on a large scale. Estimates vary, but between 70,000 and 120,000 farmers had adopted some form of conservation agriculture by 2003 (Haggblade and Tembo 2003), which amounts to about 10% of smallholders throughout Zambia. Zambia is an extensive country situated 8–18°S and 22–33°E; climate ranges from semi-arid to semi-humid. It has nine provinces, seven of which have had active support for conservation agriculture (Eastern, Central, Lusaka and Southern Provinces in agroecological regions I and IIa; Northern, Luapula and Copperbelt Provinces in agroecological region III) (fig. 1).

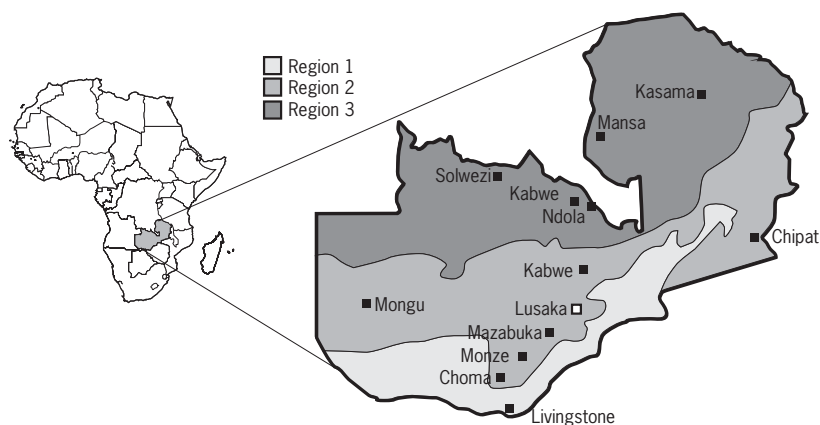


Figure 1. Agroecological regions of Zambia.

Adoption of conservation agriculture has been strongest in the semi-arid parts of Zambia (also referred to as agroecological regions I and IIa), with annual rainfall of 650–1000 mm. Farmers in these regions depend on mixed crop–livestock systems and cultivate mainly maize, groundnut and cotton.

This booklet describes a collaborative project between ACT, ASP, CIRAD, FAO and RELMA-in-ICRAF. The focus of the project was in Monze and Choma customary land areas, both situated in Southern Province (agroecological region IIa). The project itself included a literature review, interviews and working sessions with key informants, participatory rural appraisal workshops with farmers, and field visits.

The booklet describes the environment and the specific conservation agriculture technologies that have been introduced in the region, and it presents and discusses a number of key issues illustrating the successes, challenges and problems farmers experience with these technologies. Issues that have implications beyond the agricultural sector such as labour requirements for weeding and dryland preparation, soil cover management and crop rotation are hot issues within and outside Zambia. They intersect such interventions as food relief, HIV/AIDS mitigation and environmental protection.

## 2 Biophysical, socio-economic and institutional environment

### Climate

Zambia is best described as having a tropical wet–dry climate controlled by moist, warm equatorial and maritime tropical air masses characterized by three distinct seasons:

- hot and dry, from mid-August to mid-November
- warm and wet, from mid-November to mid-April
- cool and dry, from mid-April to mid-August


According to the Zambian agroecological classification, the plateau areas of Monze belong to agroecological subzone 4-east north (EN) and those of Choma to 4-east south (ES) of agroecological region IIa. The Monze area lies at an altitude of 1000–1200 m; the Choma area is slightly higher, at 1200–1400 m. Absolute daily minimum temperatures may reach 5–7 °C in the Monze area and 3–7 °C in the Choma area; absolute monthly maximum temperatures may reach 39 °C. Table 1 gives temperature data.

Table 1. Mean monthly temperatures (°C)

Seasonal variations	Zone 4-EN (Monze)	Zone 4-ES (Choma)
<i>Warm wet season (Dec. to Feb.)</i>		
Minimum temperatures	16–17	16–17
Average temperatures	21–22	21–22
Maximum temperatures	26–27	26–27
<i>Cool dry season (May to July)</i>		
Minimum temperatures	5–11	4–7
Average temperatures	14–19	13–16
Maximum temperatures	24–27	23–26
<i>Hot dry season (Aug. to Oct.)</i>		
Minimum temperatures	9–15	8–12
Average temperatures	19–24	18–22
Maximum temperatures	28–32	28–32

Classification of agroecological regions is based on rainfall variation. Mean annual rainfall in the Monze area is 750–850 mm in normal seasons; rainfall in the Choma area is 750–900 mm. In recent years, however, rainfall has declined. During the 2004/05 season, recorded rainfall for the Monze area was 769 mm, and only 505 mm in the Choma area. Up to the end of March 2006, Monze had received a cumulative total of 824 mm rainfall in 70 rain days while Choma had received 889 in 73 rain days, which corresponds to a normal rainy season.

In both subzones, the normal length of the growing season is 125 days, but recently it has been shorter due to persistent drought. Early planting is usually practised 10–30 November. The rains usually begin 1–10 December in both subzones and



usually end 10–20 March in the Monze area and 1–20 March in the Choma area. Drought periods frequently occur in both areas due to erratic and poorly distributed rainfall. Some three to four drought spells may occur per season.

Severe frosts may occur in upland areas in both zones. Annual relative humidity is classified as moderate. Strong winds are rare. The rate of relative evapotranspiration deficiency is high.

### **Socio-economic and sociocultural characteristic of families and communities**

The Tonga are the main ethnic group in both Monze and Choma areas. They are mainly small-scale land users, crop growers and livestock keepers. The Tonga people live in scattered hamlets, often separated by several hundred metres, and are administratively under the authority of a local headman, who represents the traditional chief.

Livelihoods revolve around livestock and crop production, commonly complemented by the use of natural resources. The most common animals kept are cattle, goats and poultry. Household size varies between 4 and 20 family members and polygamy is common. The households are mostly male headed but female- and child-headed households exist as well. HIV/AIDS and malaria cases have had a tremendous negative effect on the traditional family fabric, disorienting many traditional values and farming practices.

The prevalent land-tenure system offers usufruct rights around the hamlets, cropped fields and planted trees but cropland is used communally after harvest for grazing, gathering and hunting.

Funerals receive much respect among Tonga families and count for many lost person-days on the farm, especially with the increasing toll from malaria and HIV/AIDS. Many people spend a significant amount of time attending funerals, at the expense of their livelihoods.


### **Farming systems**

The Monze–Choma plateau area is basically a farming area comprising commercial farms and smallholders. Mixed farming is a common practice among both large-scale and small-scale land users, mostly integrating crops and livestock. Soils are mostly sandy loams to clay loams.

The typical farm size for smallholders is 1–5 ha, and land tenure is generally customary. Smallholders grow maize, groundnut, cowpea, sweetpotato and some cassava as common annual food crops. In addition, a range of cash crops such as sunflower, soybean, cotton, tobacco and horticultural crops are cultivated. New farm enterprises include fish farming, bee-keeping and mushroom growing.

In the Tonga culture, livestock is extremely important, both socially and in terms of numbers. Small livestock, such as goats, poultry and pigs, are easily sold to meet immediate family needs. Cattle are rarely sold, except to finance exceptional events.





such as a funeral or a climatic calamity. Most of the time, grazing is free range with a little touch of improved management and housing for the livestock. Inevitably, the animals are exposed to numerous diseases and many die. In the recent past, cattle population in Southern Province declined tremendously due to corridor disease outbreak, the extent of which is still evident today. Recently, foot and mouth disease has been found.

Conventional tillage includes an array of soil management practices in which the soil is inverted by plough or hand hoe turning over the entire soil surface. Ploughing with oxen and applying fertilizer have been the main tradition since independence, even though the crisis of the 1990s changed this situation. Since then, the number of farmers who cannot afford draught animals has increased and using the hand hoe is the most common way crops are established. Burning of crop residue and manual or ox-drawn weeding remain common practices in the entire area.

### **Infrastructure, market and communication**

Choma and Monze are the two main urban centres; the first has municipal status, the second has district status. Both towns lie on the main routes connecting the south of the country to the north by the Great North Road and the Livingstone to Copperbelt railway. The two towns, Monze and Choma, have supporting industries and services serving the farming community such as processing and handling plants, banks and communication services, and social services such as health, education and security. They also offer modern services such as mobile phones and Internet. Both towns are district headquarters and therefore house government, private and NGO offices with supporting services.

As in all Zambian towns, in addition to a main shopping centre there are designated markets where small-scale farmers sell their produce. There are also cooperatives and specialist business places dealing in non-perishable agricultural commodities at sheds.

Choma and Monze are well connected by road and railway to the north where most of the transacted produce from farmers flows but also to Livingstone, Botswana and Namibia in the south. The gravel roads into the hinterland require repair and usually impede travel. The widespread availability of trucks makes travelling straightforward, as vehicles reach town from all directions.

## **3 Description of conservation farming technologies**

In Zambia, conservation agriculture is usually known as conservation farming. The key objectives of conservation farming, as spelled out by its developers, are to

- restore soil fertility to land damaged by years of continuous ploughing (compaction and plough pan), inadequate fertility management and heavy application of inorganic fertilizers
- improve on-farm yields and incomes with moderate input use, aiming to achieve maize yields of 4–5 t/ha in typical smallholder conditions
- use rainwater efficiently

To achieve the stated objectives of conservation farming, the Conservation Farming Unit (CFU) recommends that farmers apply simultaneously the following five principles or component technologies (Aagaard 2003):

- 1 retention (no burning) of at least 30% of crop residue
- 2 land tillage of only 10–15% of the surface area without soil inversion
- 3 land preparation:
  - during the dry season to break the plough pan
  - immediately after harvest for seedbed preparation for the following season
- 4 precise and permanent grid of planting stations, furrows, pits, trenches or ridges on the contour
- 5 rotation with nitrogen-fixing legumes of at least 30% of the cropped area

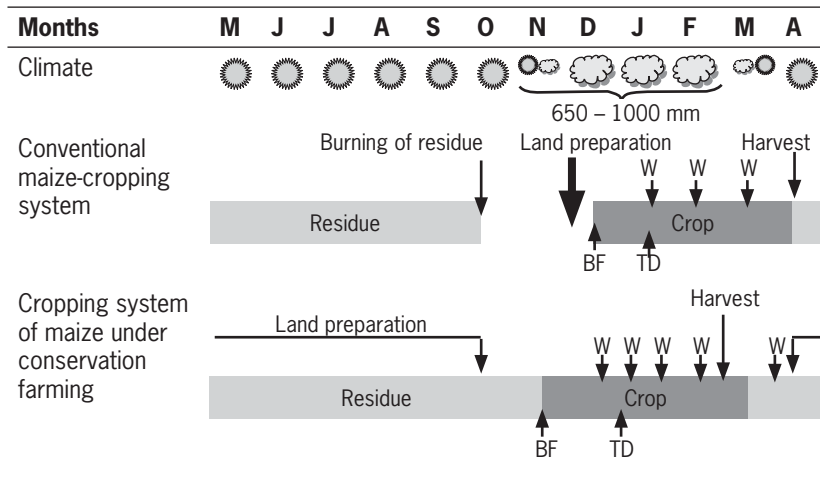
Erosion control practices can be mentioned as a sixth point, in addition to ground cover: diversion systems, terraces, contour farming (contour bunds, grass hedges, contour ploughing, etc.), and rainwater harvesting techniques.

Therefore, conservation farming can be described as a package of different techniques and practices, incorporating elements of reduced tillage, in situ rainwater harvesting, soil fertility management (including agroforestry) and erosion control, that when combined create cropping systems expected to increase sustainability of farming practices.

Replacing inversion tillage (using a plough) by reduced tillage tremendously increases weed pressure. However, a conventional hand-hoe farmer (digging planting stations but not inverting soil on the entire surface of the field) adopting planting basins does not experience any increase in weed pressure. To control the weeds without tillage, CFU recommends early and continuous weeding, with the objective of decreasing the weed seedbank over time. According to farmers and extension agents, this implies up to six weeding operations in a single maize-cropping season—that is, from the first season of adopting non-inversion practices until the weed pressure reduces. Figure 2 compares maize cultivation under conservation farming with conventional farming.

## Planting basins

The most common system based on hand hoeing is to use 'permanent' planting basins, dug during the dry season. This approach is actively promoted by CFU and others. The planting basins are shallow structures roughly 30 cm long, 15 cm wide and 15–20 cm deep that are redug each season, ideally in the same place, following a precise grid of basins (between 15,700 and 19,000 basins per hectare depending on the interrow spacing). Seeds and other inputs such as lime, fertilizer, manure or compost are precisely placed in the basins. Therefore, inputs are available for the crop to use efficiently, as they are placed close to the plant, where they are most required. The purpose of the practice is to disturb the soil only where the crop will be established, leaving the surrounding soil untouched. Basins should also improve water infiltration and are often described as a water-harvesting technique.



W: weeding – weeding; BF – basal fertilization; TD – ammonium nitrate topdressing

Figure 2. Comparison of maize cultivation under conventional farming and conservation farming.

## Ripping

If farmers own animals for draught power or have access to it, conservation farming recommends ripping (a form of reduced tillage) using the Magoye ripper (see picture section) or a similar tool. Ripping follows the same principles of reduced tillage as permanent basins: the Magoye ripper creates a groove in the soil where the seed is planted and nutrients are applied. It is desirable that the ripped lines, usually spaced 75–90 cm apart, are in the same place every year and the soil in between remains undisturbed. In theory, only the crops in the lines will benefit from the nutrients and moisture collected. To break the plough pan (and increase subsequent water infiltration and moisture retention capacity), ripping should ideally be performed during the dry season (Jonsson and Oscarsson 2002; Nolin and von Essen 2005). To avoid strain, the chain length is extended, the depth hitch point adjusted accordingly, and extended wings raised. If the soil is too hard, two to three rippings per row are recommended.

The Magoye ripper is a Zambian innovation that was developed (through Dutch funding) in 1986 in the Ministry of Agriculture and Cooperatives research station of Magoye. It has been tested locally and successfully exported to neighbouring countries in eastern and southern Africa. According to Haggblade and Tembo (2003), 5000 Magoye rippers were produced: 4000 in Zambia and 1000 in neighbouring countries.

The machine has now been modified and improved, with extended wings and a Palabana ripper planter attachment. Other equipment reducing further soil disturbances, such as the Brazilian Fitalleri direct seeder, is also being tested on-farm.

## 4 History of work related to conservation farming

### From independence to the 1990s: expansion to crisis (1964–1991)

Agricultural production increased dramatically after independence, by expanding the cultivated area and diffusing subsidized high-input systems of maize-based production. Large-scale support for maize marketing was coupled with extensive fertilizer and input subsidies and tractor and plough credits. Rental schemes were also subsidized.

This system rapidly reached a limit due to yield decline, change in rainfall patterns and a decline in capital available to and accessible by smallholders. Land degradation due to conventional tillage and excessive use of inorganic fertilizers became highly visible in Southern Province. Continuous use of drawn implements during periods of high moisture content, usually at the same depth, has led to compact plough pans that restrict water movement and oxygen availability and inhibit normal root growth. In Southern Province, the widespread plough pan problem on many fields has contributed to a significant number of households migrating to other lands. For example, 'New Monze' in Central Province was created by immigrants from Monze.

In 1991, an abrupt end to maize subsidies, when agricultural marketing was liberalized under the Structural Adjustment Programme, further threw the smallholder sector into turmoil. Withdrawal of subsidies for farm inputs and commodities was associated with a tremendous increase in fuel price.

In the same period, a major outbreak of corridor disease struck up to 90% of cattle in Southern Province. Farmers in economic distress often sell off oxen to get cash. When they did this, a common, direct effect of the epidemic became using cows for draught. Major droughts were also recorded, particularly a severe one during the 1991/92 season.

Poor yields, exacerbated by drought and disease, brought on a credit breakdown. Interest rates on seasonal loans rose sharply and lending operations declined significantly. This transformed the small-scale farmer into an extremely unattractive business partner for the private sector. Current maize yield levels in Zambia cannot sustain the credit repayment requirements of small-scale farmers in Zambia. Collapse of the traditional agricultural lending institutions has worsened the situation. Southern Province used to be a net exporter of agricultural products, but it became a net importer after the drought of 2000/01.

### Spontaneous responses of smallholders

Within this context of crisis, farmers reduced the amount of fertilizer used by 66% and diversified away from maize. The most evident example is the widespread adoption of sweetpotato, cowpea and some cassava in new areas. Food security increased as farmers started to grow crops more suitable to the changing environment and less dependent on external inputs and by engaging in new enterprises.

Low-input farming systems became more prevalent. Production became more and more dependent on the natural fertility of the soil, mining the system of its nutrients, without proper fertility management. Rarely, however, more sustainable systems were also adapted and adopted, integrating legumes and practising proper crop rotation.

Outgrower schemes with contract farming have also increased rapidly in some areas as farmers had limited knowledge and funds to venture into new crops. The schemes usually assist with both credit and training for specific crops. Farmer collaboration and organization have also increased through farmer groups, associations and cooperatives.

### **Genesis of conservation farming in Zambia**

Intensive tillage and lack of soil cover, especially due to the common practice of burning residue, were soon perceived as major causes of soil degradation. Ploughing and hand-hoe ridging increase the diffusion of gas ( $O_2$ ) and increase oxidation and mineralization of soil organic matter, rapid under tropical conditions, as well as speeding up hard pan formation. Burning of residue reduces recycling of organic matter; it converts N, S and part of P into gases. Moreover, K, Mg, Ca and part of P remain in the ashes, which might be washed away by runoff.

Also within the crisis context, in the late 1980s a number of key stakeholders actively participated in testing minimum tillage, crop rotation and crop association. A growing coalition of stakeholders from the private sector, government and donor communities has been promoting a new conservation farming package of agronomic and land management practices for small-scale land users in Zambia. Chiefly among them are ZNFU/CFU (Zambian National Farmers Union and CFU), IMAG (Institute of Agricultural and Environment Engineering), GART (Golden Valley Agricultural Research Trust), Dunavant, CLUSA (Cooperative League of the USA), LM&CF (Land Management and Conservation Farming—today ASP), MACO (Ministry of Agriculture and Cooperatives).

ZNFU's initial interest in minimum tillage began when several commercial farmers in ZNFU travelled to Australia and the USA in the early 1980s. Reduced fuel consumption was the principal incentive for these farmers to adopt conservation farming; minimum tillage had the potential to reduce fuel consumption from 120 to 30 litres per hectare. ZNFU started trials on permanent basins in 1995 at GART, using the experience and first successes of Brian Oldreive in Zimbabwe. The same year, CFU was created to adapt and promote hand-hoe basins under Zambian conditions, with the aim of developing systems that would produce 6 to 8 t/ha of maize. CFU played a major role in adapting conservation farming to small hand-hoe farmers. The number of demonstrations and trials of CFU under farmers' conditions reached 395 during the 1996/97 season and 800 during the 2001/02 season.

Backed by funds from the Swedish government in 1985, SCAFE began to disseminate erosion control methods and soil fertility enhancement techniques across the region. Activities of SCAFE began in Eastern Province and expanded to Lusaka, Central and Southern Provinces in the mid-1990s. In 1986, MACO transformed SCAFE

into LM&CF. In 1986, ICRAF worked on soil rejuvenation using improved fallows in Eastern Province. The purpose was to find natural fertility enhancers in the face of the high prices being charged for inorganic fertilizers. Herbaceous shrubs such as *Sesbania sesban*, *Tephrosia vogelii* and *Gliricidia sepium* proved to be the most suitable plants to grow under typical farm conditions.

### **Government and donor support (1999–2003)**

Many entities identified the wide-scale adoption of conservation farming as a key tool for redressing the small-scale farmer situation (MAFF 1999; Jonsson and Oscarsson 2002; GART 2004a). A tremendous increase in the number of conservation farming adopters was observed from 1999 to 2003, due to government and donor push.

In 2000, MACO formally embraced conservation farming as an official policy of the Zambian government (MAFF 2001). In fact, the government has supported conservation farming in various ways: policy pronouncements, workshops, demonstrations and field support. The World Bank facilitated the training of all extensionists in agroecological region IIa, including key staff from MACO headquarters, in 'fast-track technologies' (MAFF 1999). Fast-track technologies are 'best-bet' practices tested for over three seasons and believed to be well suited to the conditions of agroecological regions I and IIa. These basic components of conservation farming comprise an obligatory sequence of practices referred as 'non-negotiables', to which are added 'negotiables', which are dependent on the particular circumstances of the farmer (see appendix 1). To simplify implementation and monitoring of the programme, these were limited to a 6-lima package<sup>1</sup> (2-lima food crop, 2-lima cash crop, 2-lima leguminous crop). The specific crops grown were chosen in accordance with agroecological region requirements. On a much smaller scale, some farmers were trained on medium-track technologies, a group requiring further research or requiring a longer lead time due to the need for comprehensive training, a higher level of management, or establishment of propagation nurseries. Such technologies include use of cover crops, agroforestry, live fencing, erosion control methods, manure and compost. Frontline extension officers, 620 in number, from Central, Eastern, Lusaka and Southern Provinces plus Kaoma District of Western Province were concurrently trained in fast-track conservation farming technologies at four training sites (Chalimbana, Katopola, Palabana, ZCA-Monze), from 28 May to 21 June 2000 by MAFF's Land Husbandry Section and CFU. All trained field staff and senior staff were then tasked to establish their own conservation farming plot to learn and practise the technology as a promotional effort. CFU monitored these demonstrations and assessed their performance value.

To date, MACO has trained almost all extensionists in the above-mentioned areas on proven fast-track technologies, and it has increased training on broad-based medium-track conservation farming technologies for staff from Copperbelt, Northern, and Luapula Provinces, where precise conservation farming recommendations have yet to be developed.

<sup>1</sup> 1 lima = 0.25 ha

During the season 2002/03, Sida, Norad, FAO and WFP promoted digging permanent basins through the programme Food for Work. At the same time, CARE, CFU, CLUSA, LM&CF, PAM and World Vision distributed 60,000 input packages to cultivate 1 lima of maize and 1 lima of legume. Many NGOs continued training. However, Food for Work programmes sometimes compromised the technology by having workers simply dig substandard ordinary planting basins.

## 5 An overview of the conservation farming diffusion process

Many institutions and organizations, principally MACO and CFU but also to a lesser extent a variety of NGOs, have been adapting and disseminating conservation farming technologies with support from bilateral and multilateral partners, programmes of Land Management and Conservation Farming (LM&CF), supported by Sida, and the Conservation Farming Technologies Component, supported by UNDP, supplemented government efforts to support a variety of smallholder conservation farming-related activities from 1991 until 2002 in seven provinces (all except North-Western and Western Provinces).

Some organizations involved in the technical development and dissemination processes associated with conservation farming used a rather conventional linear approach: technical packages are developed on station, demonstrated on-farm, and diffused to individual farmers then later to farmers usually belonging to a cooperative or a farmers' organization. This was the approach followed when developing machinery for conservation farming. The diffusion process for field activities was on-farm. Trials were conducted on farmers' fields, and learning, modification and promotion were all done there. CFU gathered more than 3200 observations from farmers' trials and demonstrations (CFU, pers. comm.).

Input packs of seeds, fertilizers and lime were provided to farmers free or on a cost-sharing basis. They constituted a strong incentive for short-term adoption as they decreased the risk associated with trying out and learning conservation farming techniques, thus strengthening diffusion. Incentives, however, are not always required for adoption. For example, 6000 small-scale cotton farmers, under contract with Dunavant, spontaneously adopted conservation farming without receiving any support for their conservation farming activities (Haggblade and Tembo 2003). Diffusion was strengthened by the Zambian government's adoption of a conducive policy framework for conservation farming.

The diffusion process showing the different components used in Zambia and the major stakeholders involved in each component is summarized in table 2.

Regular interaction occurs informally across this broad consortium of conservation farming practitioners. In 2001, MACO's Technical Services Branch established a national conservation farming steering committee, with representation from all major stakeholders in the agricultural sector, to help coordinate information flows and facilitate collaboration (MAFF 2001).

Table 2. Major stakeholders and component of conservation farming diffusion in Zambia

Activity	Lead stakeholders	Other key stakeholders
Awareness creation	ASP, MACO	GART
On-station experimentation and adaptation	GART, MACO	—
On-farm demonstration plots and trials	CFU	GART (ADP reduced tillage equipment), RELMA
Field demonstration, field days and field visits	CFU, GART, ASP, MACO	—
Exchange visits and study tours	FAO	—
Specialized training for extensionists	CFU, MACO	—
Training for farmers	CFU, MACO, ASP, CLUSA, Dunavant	CARE, PAM, DAPP, World Vision
Formal extension and technical assistance	MACO, IDA, UNDP, FAO, Sida	Dunavant, CLUSA
Input supply	Sida, Norad, FAO, WFP	—
Implement supply	SASWAZ, MACO	Africare
Credit	CLUSA	—
Local institutional strengthening	MACO, CLUSA, ASP	—
Monitoring and evaluation	CFU, ASP, INESOR, ECAZ	—
Policies	MACO	—

## 6 Conservation agriculture adaptation

### Muyamba pits

Muyamba pit farming is a farmer-generated technology based on indigenous knowledge. Named after its innovator, Mr Petrus Muyamba, the Muyamba pit adapts principles of conservation farming to local conditions. These structures are basically fertility pits 160 cm in diameter and 60 cm deep into which 20 maize plants are planted, although the size may vary. Each pit is filled with crop residue, compost, manure or cut grass, layered with soil on the top. Applying farmyard manure, compost, or dried green manure such as *Gliricidia sepium*, *Leucaena leucocephala*, *Sesbania sesban* or *Tithonia diversifolia* in the pit enriches the soil fertility status further than just crop residue and other leafy dry matter. The decomposed material provides sufficient nutrients for three or four seasons and further inputs during this time may not be necessary (Nolin and von Essen 2005; Mwanza unpublished). For this technique, biomass available in the surrounding area may be a limiting factor. Similar innovations have been recorded in East Africa (chororo pits in Tanzania) (Critchley et al. 1999). For these two techniques, biomass availability in the surrounding area might be a limiting factor.



## Fertility trenches

Fertility trenches can also be considered a local adaptation of hand-hoe conservation farming. The technique shares similarities with both permanent planting basins in the sense that tillage is annual, and Muyamba pits in the sense that reliance on external inputs is minimal. A continuous trench 15–20 cm wide and 15–20 cm deep is dug, usually with a Chaka hoe or a mattock. The soil is removed, placed on one side and later backfilled after the trench has been filled with crop residue or other soil fertility improvement matter (Mwanza unpublished). Variants of the trench now reach 30 cm width to incorporate more organic matter material. Principles remain the same as for planting basins.

## Hand-drawn equipment

Some farmers, without adequate animal draught power or the Magoye ripper, modified existing ploughs (Nolin and von Essen 2005) or even fabricated their own ripper.

# 7 Impact of conservation farming

With dryland preparation being recommended, a key advantage of conservation farming is that it allows farmers to commence land preparation earlier than conventional practices, thus facilitating early planting (fig. 3). Early planting enables the crop to use the first effective rains and to benefit from the nitrogen flush. Early germination and enhanced root establishment increase yield potential markedly; otherwise, maize yields fall 1–2% for every day planting is delayed after the first possible planting date, while cotton losses are estimated at 250–350 kg/ha per week delayed (Haggblade and Tembo 2003). A normal plough-hire scheme among kinsfolk implies a reduction of 30% to 60% of the potential yield. Early planting also allows farmers to concentrate on weeding during the weed flush rather than ploughing and planting, as is the case in conventional farming systems. Moreover, conventional land preparation corresponds to a period of reduced and weak farm labour due to food scarcity and higher incidence of malaria at that time. For adopters of conservation agriculture, the entire farming calendar is in fact moved toward the dry season, meaning that farmers plant early, weed early, harvest early and attain food security early. Land preparation commences soon after harvest when the land is not too hard for most of tillage operations (except for deep tillage aiming at breaking hardpan).

When cultivating cotton and maize by hand hoe in conservation farming, farmers commence land preparation in May–June and spread labour requirements over a longer period of time. The activity calendar becomes more flexible for conservation agriculture farmers. Spreading demand for labour also allows households, especially women and children, to carry out lighter tasks and diversify their activities.

Conservation farming promoters argue that even though suppression of inversion tillage increases time and labour dedicated to weeding, and therefore total labour demand, redistribution of the heavy land preparation to the dry season compensates for it, as this is time during which no other agricultural activities compete for

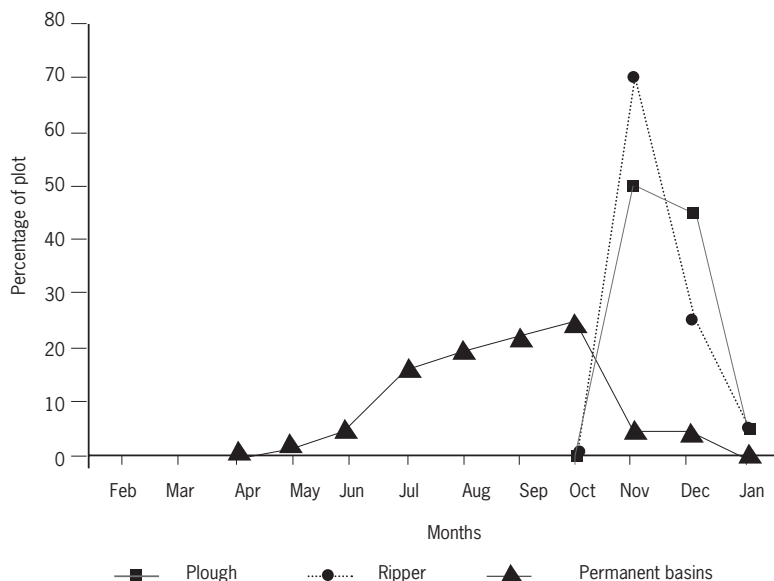


Figure 3. Timing in land preparation in different maize systems (Haggblade and Tembo 2003).


household labour. Moreover, conservation farming promoters strongly insist on using alternative weeding methods such as herbicides, cover crops and mulching to reduce weed pressure and labour demand. It seems also that the better yield and gross margins expected drive farmers to plan and implement throughout the year, avoiding the labour bottlenecks when activities are concentrated in a short period of time. Table 3 describes a continuous weeding regime. In reality, farmers manage at best two or three weeding operations.

Table 3. Schedule for a continuous weeding regime

Stage of maize development	Weeks after planting
Preemergence	0-1
Postemergence	2-3
Pretopdressing	4-5
Pretasselling	7-9
Cobbing	12-15
Postharvesting	18-21

### Planting basins

A sample of 125 hand-hoe farmers using conservation farming was found to produce 1.5 tonnes more maize and 460 kg more cotton per hectare than did farmers practising conventional ox-plough tillage (Haggblade and Tembo 2003). Improved yields under conservation farming resulted from a suggested combination of early planting, rainwater harvesting and better infiltration rates, and increased precision



in applying inputs (Nolin and von Essen 2005). Up to 30% of seasonal rainfall and 50% of applied nutrients are lost in runoff with conventional farming, and infiltration is significantly higher in basins than in ploughed fields (Nolin and von Essen 2005). Fertility investment around the plant accounts on its own for 400–500 kg of extra yield per hectare for cotton and 700 kg for maize.

## Ripping

As with planting basins, using the Magoye ripper enables

- early land preparation and early planting—optimal benefit from scarce and erratic rainfall, and therefore timeliness in the first weeding (weed flush)
- efficient use of rainwater, suppressing plough pan, thus increasing infiltration since soil macropores remain open where the soil has not been disturbed
- expansion of cultivated areas within the available time and farm power

Maize grown in ripped rows has been observed to grow much faster with higher vigour than that grown under conventional practice due to concentrated inputs and soil moisture (GART 2004b). Farmers also consider the ripper considerably faster and easier to handle than a plough and say it forms homogenous furrows at a depth where seeds germinate well.

However, yield gains for maize with the ripper compared with the plough are slight. In certain years, no significant difference has been observed. Indeed, farmers using rippers in conservation farming did not perform as well as farmers using hand-hoe conservation farming basins. The poorer performance of rippers under on-farm conditions may be attributed to a slight loss in precision of both plant spacing and fertilizer application compared with basins.

## 8 Adoption of conservation farming

### Planting basins

CFU estimates that around 78,000 small-scale hand-hoe farmers were practising a form of conservation farming during the 2002/03 season (around 9% of small-scale farmers in Zambia), which makes the Zambian experience one of the main success stories of conservation agriculture in sub-Saharan Africa. Estimates were that 35,000 farmers had adopted improved reduced tillage, 25,000 conservation tillage, and 18,000 conservation farming as a whole.

Most of these adopters, however, have not adopted all of the principles. Less than a quarter are applying conservation farming as recommended. A third do not practise crop rotation; almost half practise neither crop rotation nor residue retention. Most farmers have indeed tried and adapted different tillage techniques in different ways, but not always as recommended.

Farmers who apply only principles 1 to 4 (see page 5) are said to be practising conservation tillage. If they only apply principles 2 to 4, they are said to be practising improved reduced tillage. Indeed, only about 25% of farmers practising

some sort of conservation agriculture do practise its fullest form—principles 1 to 5—conservation farming in its real sense.

If conservation farming adoption is partial in terms of principles, it is also partial in terms of cultivated area. Farmers usually perceive conservation farming as a complement to their regular cropping system rather than an alternative to it. It is usually adopted on only part of the farm, typically 1 lima. Such partial adoption may be due to a number of on-farm reasons.

### **Magoye ripper**

During the 2002/03 season, it was estimated that only 4000 to 6000 farmers practising conservation farming used the ripper (Haggblade and Tembo 2003). This low level of adoption can be partially explained by the fact that the implement is not widely available in the country.

A number of farmers believe the ripper is not suitable for every type of soil and particularly that the chisel tine is not strong enough for certain soils. Moreover, most ripper owners use the ripper as a tillage tool at the onset of rain rather than as a dry-season tillage implement. It is also surprising to note that there are more Zambian Magoye rippers being used in Tanzania than in Zambia.

## **9 Present gaps and challenges: ‘burning issues’**

Figure 4 synthesizes the main constraints hampering successful implementation and large-scale adoption of conservation farming and the subsequent achievement of its potential benefits in Monze and Choma.

### **Conservation farming and labour constraints**

Conservation farming increases labour use for weeding in the first year it is adopted (table 4). Extension staff confirmed that conservation farming using basins almost doubles weeding effort compared with the conventional plough system. Similarly, it increases labour requirements for preparing land the first year.

Managing increased weed population is the main problem. Most conservation farming adopters interviewed within the context of this case study manage at best to do two or three weeding operations during the cropping season instead of the recommended six, allowing weeds to produce and disseminate their seeds. Increased weed pressure is a problem for both hand-hoe conservation farming and ripping. For the latter, advantages of using a ripper (easy and quick land preparation, etc.) are counterbalanced by the limited labour force available, which is unable to face the increased demand for weeding (Nolin and von Essen 2005). Ripping might have the potential to increase the surface area planted, but the system is still dependent on hand weeding—even ox-farmers using a cultivator or extended wings need to weed manually between plants.

Those promoting conservation farming argue that labour demand decreases progressively year after year when farmers follow recommendations and gain more experience. Labour required the first year to dig basins is halved after five years, if

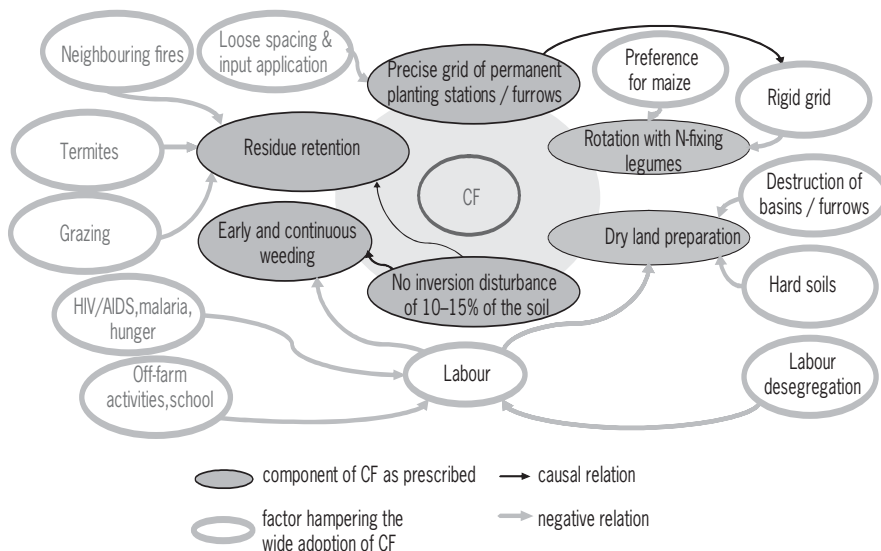


Figure 4. Components of conservation farming (CF) as recommended and related constraints.


Table 4. Labour required for preparing land and weeding cotton in conservation vs conventional farming (1 day = 8 hours)

Type of cotton cropping system	Labour for weeding (workdays/ha)	Labour for preparing land (workdays/ha)
Conventional ploughing system	45	7
Conventional hand-hoe system	70	59
Conservation farming using basins	80	66

Source: Haggblade and Tembo 2003

these basins are permanent from one season to the other. Similarly, research from GART suggests that labour for weeding is reduced by 50% after six years of trials, during which weeds are not allowed to grow beyond 5–6 cm in height. However, it is obvious that six weeding operations per season during the first years acts as a significant disincentive to adopting conservation farming. The increase in labour requirements may be incompatible with the labour bottlenecks most smallholders face.

A household can cultivate up to 1 ha under conservation farming, but it would have to hire casual labour to expand. However, use of casual labour is culturally not widely accepted, and rural daily wage rates during planting and weeding correspond to the peak, ranging from ZMK 3000 to ZMK 5000 (USD 1–2), further discouraging many families. Certain conservation farming promoters advocate family approaches to face increased labour demand, meaning that every member should participate in every task. However, organizing labour in this way is usually not compatible with



traditional labour disaggregation. Culturally, men prepare the land by ploughing, and women and children plant and weed. Competition with off-farm activities, school and paid employment in particular, also explains the labour constraints. The HIV/AIDS pandemic has recently exacerbated the situation through its negative effect on the working ability of the affected adults and the social obligation for household members to attend funerals and spend less time participating in farming activities.

### **Peak labour and dry land preparation**

Dryland preparation advocated by conservation farming promoters is rather theoretical as it coincides with maximum soil hardness. Thus, digging basins manually becomes difficult. The option would be to make them immediately after harvest, but this poses problems of labour availability, habits and competition with off-farm activities. Moreover, farmers indicate that roaming cattle tend to destroy basins dug during the dry season, obliging farmers to repeat the task at the beginning of the rainy season. For these reasons, 10–30% of the basins are dug at the onset of the rains, taking away part of the benefits of conservation farming.


Most farmers using the Magoye ripper (70% of the users) use it at the onset of the rains, thus preventing reaping the expected benefits associated with early planting and water harvesting. No significant difference in crop yields is perceived, therefore, between ripping and conventional ploughing. Farmers usually state that dry-season ripping is difficult, even with four oxen, and that the resulting depth is usually inadequate. However, such difficulties are usually caused by not adhering to principles and practices, such as correct chain length and depth adjustments. With weak animals or hard soils, two or three rippings per row might be necessary.

### **Residue and biomass management**

Conservation farming promoters insist on crop residue retention and soil cover as key parts of conservation farming. Interviews carried out during this case study showed that termite activity under conservation farming is generally said to increase with the presence of dry matter in the fields. Some farmers, however, regard it as a threat to their crop, and thus a point for resistance to wider adoption of conservation farming. It is also a common belief in Southern Province that the practice of conserving residue on the field harbours pests and diseases. Traditional extension system practices of keeping fields clean have also persisted while there are still believers that burning crop residue improves the soil.

However, if the great majority of conservation farming adopters seem to have stopped burning crop residue in recent years, soil cover may still be subject to neighbouring fires, unless clear fireguards and other fire control measures have been put in place (which represent additional labour). Indeed, retention of 30% of previous crop residue as recommended by conservation farming stakeholders is seldom achieved. This is mainly due to the fact that croplands become communal grazing lands between harvest and the beginning of the next cropping season.

During the dry season, crop residue (and other soil cover such as cover crops) are virtually the only source of forage for livestock—important in the Monze–Choma



area. Communal grazing and roaming cattle reduce drastically the soil cover. Furthermore, many of those who no longer burn their residue prefer to transport it to feed their cattle or make compost rather than leave it as soil cover (Nolin and von Essen 2005). In the Monze–Choma area, cattle are extremely precious and crop residue are used as dry-season forage rather than as soil cover. Residue retention seems to be perceived as a paradox by many smallholders and not a feasible practice under Southern Province conditions. The usual inconsequential biomass is, we believe, a main limiting factor in the performance of the system, especially in terms of weed populations.

Despite these challenges, there are situations where good management of crop residue has yielded positive results. The issue of land tenure and user rights at community level requires addressing; then local headmen, with increased awareness and mutual trust, can achieve better results.


### **Crop rotation**

The Conservation Farming Unit recommends that 30% of the cultivated land be planted with a nitrogen-fixing crop to be rotated with maize and cotton. This may prove to be too inflexible when outside factors such as markets and demand for produce are taken into account. Discussions with farmers experienced in conservation farming suggest that a conservation farming plot is not part of a rotation sequence. Rather a portion of land outside the main fields is set aside for conservation farming as insurance against drought and famine for family food security.

Households usually favour maize cultivation and, due to shortage of labour, cannot grow other crops in areas suitable to be part of a proper rotation with maize (Nolin and von Essen 2005). Moreover, in the Monze–Choma area, inadequate crop rotation can partly be a cultural trait: men traditionally grow the main crops of maize and cotton, and women grow minor crops such as groundnut and cowpea. This disaggregation challenges proper crop rotation. Cash crops and maize, for example, will always be grown on a larger scale than groundnut.

It seems that many farmers do not perceive the importance of crop rotation. A farmer questionnaire administered in two camps of Southern Province revealed that, even though 98% of the farmers believe rotating maize with sunn hemp or velvet bean yields better, 91% consider that the crops in a field need to be changed only when the yield starts to decline (Nolin and von Essen 2005). More training and awareness on the subject might be required. Various authors are of the view that many organizations have promoted the tillage aspect in conservation farming more than other parts of the concept. It would appear that somehow the organic matter aspects have been lost, especially crop rotation, which has not been as thoroughly promoted despite its importance, maybe because present institutions still focus on tillage.

Many farmers interviewed also considered that the recommended grid of permanent planting stations was too rigid and not suitable for certain crops (such as soya and other beans or horticultural crops) to be cultivated according to their optimum planting density.



Nolin and von Essen (2005) conclude that crop rotation, as conservation farming prescribes it, is one of the greatest problems farmers face. At best most farmers interrupt several years of maize by one season of alternative crops.

### **Subsidies and adoption**

Undoubtedly the convergent approach to promoting conservation farming followed by basically all Zambian stakeholders (from policymakers and donors to input suppliers and trainers) has produced impressive results so far.

A central component of this approach has been the provision of input packages to farmers, whether free or on credit, including seeds, fertilizers and lime, as a way to reduce and share the risk farmers take when introducing conservation farming. These packages are being offered to smallholders who accept to apply 'non-negotiable' conservation farming principles on at least part of their farm. However, 50% of farmers drop conservation farming after having been disqualified from CLUSA or CFU programmes for not having been able to pay back their credits. Hence, the question arises whether farmers adopt conservation farming as a way to get access to subsidized or free inputs or because they are convinced that conservation farming is good for them. But conservation farming activities seen on some farmers' fields indicate that a number of farmers are convinced that this is the way forward.

This issue is compounded by the fact that part of the yield increase observed under conservation farming is due to higher input use, strongly recommended under conservation farming. As was the case with the incentive scheme, this may generate confusion among farmers about the actual causes of increased productivity; conventional smallholders are rarely able to afford adequate fertilizers.

### **Lack of tangible data demonstrating conservation farming as economically viable**

Most adopters of conservation farming use hybrid seeds and fertilizer on credit from their sponsoring agencies (CLUSA or CFU) and most ox-plough farmers do not (Hagglblade and Tembo 2003); therefore, part of the yield difference arose due to higher input use under conservation farming. Also lacking are impact studies applying controls to conservation farming trials and demonstration plots. Conservation farming yields are usually compared with national average yields. This is confusing to most smallholders. Matrixes with different levels of input (including no input at all) comparing conservation farming with conventional farming should be put in place to remove this confusion.

Conservation farming has been included in the policy framework for food security of households and the nation as a whole. Although this is a worthy step, it biases the perception of the technique towards food security measures for vulnerable households rather than as a way to farm as a business. The message of diffusing conservation farming to achieve food security for hand-hoe small-scale farmers should be rounded out with a message that conservation farming is part of modern productive agriculture, even at a commercial level. In Southern Province, there is a Tonga saying, 'You cannot be rich with conservation farming.'



## Precision

Precision and standards are parts of the package (Oldreive 1993), but they require a discipline that many small-scale farmers cannot achieve. They move basins every two or three years instead of making them permanent. Some farmers even do not understand why basins should be made permanent (Nolin and von Essen 2005).

However, while some organizations argue that many farmers using the Magoye ripper may not maintain the accuracy of planting in the same line every year like hoe farmers (Siacinji-Musiwa 1998), others feel that with better training of draught animals and users, it is possible to maintain the same planting lines to the greater benefit of the conservation farming adopters (Jonsson and Oscarsson 2002).

## 10 Discussion: the way forward

Given the hindrances discussed here, a number of adjustments need to be brought on board to increase both the performance and the adoptability of current conservation farming recommendations and practices. Several options are being pursued, and their relative advantage and drawbacks are here discussed briefly.

### Using herbicides and cover crops

#### *Use of non-selective herbicides*

Most conservation farming promoters perceive the use of non-selective herbicides, such as glyphosate, as the way to solve the labour bottlenecks related to weeding, as they enable fast control over a large area. To this end, CFU developed a simple, low-cost, robust and effective herbicide-spraying device: the Zamwipe. This device reduces labour drudgery from 50–70 person-days per hectare to 15–20, dramatically increasing returns to labour (GART 2004a). A trial with Zamwipe over three seasons showed a saving of USD 26.5 per hectare when compared with the usual hand-hoe weeding. In the recent seasons, demonstrations have been using both selective and non-selective herbicides.

However, the use of non-selective herbicides and spraying devices even as simple as the Zamwipe requires adequate training and knowledge in terms of quantities to be used and time of spraying. This is a requirement that should not be underestimated in small-scale farming. Furthermore, discussions with farmers conducted during this case study showed that farmers were sceptical about the long-term effect of glyphosate application on the soil, arguing that if it can 'wipe' weeds, what would stop it from sterilizing their soil in the long run? Some farmers indeed believe that reduced weed pressure in the field is a sign of reduced soil fertility.

#### *Quality and precision of crop management*

Another avenue for solving the weed problem and increasing productivity is to insist on the quality and precision of crop management that farmers need to achieve under conservation farming, which will result in more homogenous crop canopies and eventually higher yields (Brian Oldreive, pers. comm.). This argument, which

may resonate with farmers who are ready to invest a lot of energy and time into crop management, may not change the way the average smallholder farms. However, manipulating interrow spacing as a way of weed control is something worthy of further investigation.

### **Cover crops**

Increasing soil cover by incorporating cover crops could also contribute to controlling weeds, among other benefits. A cover crop is a fast-growing crop with a dense stand grown for the purpose of shading and covering the soil, to protect it from erosion, to increase water infiltration, to suppress weeds, to add organic matter, and to improve soil structure. According to the Zambian definition, cover crops are leafy crops, mainly leguminous, grown in association with a major crop to enhance its performance. For other organizations (CIRAD, FAO, etc.) or in other parts of the world (Brazil, Kenya, Tanzania, etc.), cover crops might also include crops grown in rotation with the main crop, to produce biomass and improve soil structure; in Zambia these are commonly known as improved fallows.

Cover crops may quickly cover up to 90% of the interrow spacing. Cover crops are also said to sequester carbon due to their large photosynthesis activities that capture, convert and store carbon in the soil (GART 2004b).

The use of cover crops has long been a hotly debated issue among conservation farming promoters in Zambia. Perceived as a 'useless sophistication', screening locally adapted potential cover crops has been a low priority for research and extension in past years. However, recently things have changed as ZARI and GART are currently testing several potential cover crop species for the different agroecological regions of Zambia. The purpose of this research is to integrate cover crops in farming systems for Zambian smallholders, for major crops: maize, sorghum, cassava and sunflower. Cover crops that performed well across the experimental setup include velvet bean, mucuna (green and Sommerset varieties), *Dolichos lablab*, jack bean (*Canavalia ensiformis*), rice bean, cowpea and sunn hemp (*Crotalaria* sp.).

Proposed species of improved fallows in Southern Province include sunn hemp (*Crotalaria juncea*), pigeon pea, *Tephrosia*, *Sesbania* and *Gliricidia*.

Associating a cover crop with the main crop should be easily accepted by smallholders, perhaps more than improved fallows, as intercropping with creeping plants (especially pumpkin, gourds and cowpea) is a traditional technique, even though it has been described by certain authors as being done haphazardly and could be improved using better varieties (Raussen 1997). The choice of possible cover crops is a challenge in Southern Province, considering the harsh conditions of its long dry season. Moreover, cover crops have to be multipurpose, as many farmers expressed that an immediate gain in food, forage or cash was required to counterbalance the extra work (and extra land in the case of improved fallow grown in rotation) associated with their use. Communal grazing after harvesting is an additional problem that may hinder the use of cover crops.

### ***Magoye ripper with extended wings***

Extended wings attached to the ripper assembly were developed to control increased weed population in fields of adopters of this implement (whose cultivated surface area is thought to be greater than that of conventional plough farmers). For cereals, two weeding sessions are recommended: one just after germination and one when the crop is about knee-high (Jonsson and Oscarsson 2002).

### ***Bylaws***

The alternative to achieving a proper soil cover under conservation farming would be for farmers and communities to change their bylaws and traditional local rules so that they could control communal grazing. Such changes are not easily accomplished. The diversity with respect to possession of livestock among households is wide, with the wealthier and more influential families benefiting the most from communal grazing. This is an avenue that until now has hardly been tried let alone achieved in Zambia.

During the participatory rural appraisals conducted for this case study, it was interesting to hear from farmers that early land preparation could prevent herds from entering the field. Cattle herders would not consider tilled land as part of the communal grazing area, especially when planting basins and pits have been made.

## **Facilitating dry-season land preparation**

### ***Chaka hoe***

The Conservation Farming Unit has developed the Chaka hoe, a heavy hoe that can be swung to reduce effort, and makes the task of preparing dry season basins possible. Two adults are said to be able to dig 400 basins in three hours with the Chaka hoe. This still translates into approximately 40 days of dry season labour to prepare 1 ha of basins, which would discourage many potential adopters. A number of well-trained farmers have adopted it, however, and perceive a definite advantage in using it.

### ***Sunn hemp fallow for ripping systems***

In 2003/04, CFU developed a ripping system for a sunn hemp fallow system that enables deeper and easier ripping in late March, when the soil is still moist, and allows timely planting. Moreover, improved fallow such as sunn hemp may improve soil fertility over time, be a source of fodder and soil cover, and contribute to weed control. The opportunity cost of land seems compatible with such a system, since most ox farmers and previous ox farmers have far more land than they cultivate, allowing them to introduce such improved fallows on their farm. However, due to limited labour and lack of markets, incentives to grow such cover crops are low. Multipurpose cover crops able to generate food or a marketable product need to be explored further.

## Increased reliance on animal draught power ('oxenization')

Zambian households gain access to animal draught power in several ways. A third of the estimated 226,000 households using draught power actually own the animals, about 20% rent them, and 45% borrow them (table 5). These differences correlate with the area cultivated (bigger for draught power owners) and also to timeliness of planting (earlier for them). Animal draught power owners first satisfy their own requirements before they permit others to use their animals; and they give preference and more time to households that hire than to households that borrow the power. A normal plough rental scheme implies a reduction of 30% to 60% of the potential yield (Haggblade and Tembo 2003). Conservation farming promoters in Zambia, and CFU in particular, argue that ripping would allow all categories of draught power users to spread land preparation into the dry season, thus increasing the proportion of those able to plant earlier, even among borrowers. Besides higher yields, this would also offer an opportunity to expand the cultivated area and hence increase overall production. However, the major problem of using the ripper as a dryland preparation tool has to be solved for such large-scale benefits to be realized.

Table 5. Smallholders using animal draught power and effect on their farming systems


Smallholder options	Using animal draught power (%)	Average surface cultivated (ha)
Own adequate animal draught power	36	2.83
Hire animal draught power	19	1.64
Borrow animal draught power	45	1.39

Source: Haggblade and Tembo 2003

## Increasing flexibility in approach to conservation farming development and diffusion

Existing evidence amply proves that conservation farming allows Zambian farmers to improve crop yields and productivity per area. But as it is being diffused officially as a food security and drought-mitigation technology, many farmers perceive it as something for vulnerable households and not as a modern, and commercial, way to farm.

However, increasing profit or attaining food security might not be major objectives that many farmers are keen to achieve. For example, spreading income or freeing time for off-farm activities might be as important, or even more so, for farmers looking to introduce relevant innovations into their farming systems. Unfortunately, scant information exists on such issues. Until now, farmers' norms, culture, attitudes and objectives have not explicitly been taken into account to develop, adapt and diffuse conservation farming in a differential or targeted manner, depending on the specific problems, constraints and objectives of farmers. Use of more participatory ways to innovate, coupled with greater flexibility in the conservation farming package, would probably contribute to increased, more sustainable adoption of conservation farming among smallholders.



The question is whether to prescribe a complete combination of techniques to farmers or to encourage them to choose among a basket of techniques. It would appear that government promoters are more flexible than NGO promoters in these matters.

## 11 Concluding remarks

One of the main lessons learned from the Zambian experience is that all stakeholders united around a simple system—from policymakers and donors to input suppliers and trainers. The policy framework put in place by the Ministry of Agriculture and Cooperatives is remarkable and should be strongly highlighted.

Conservation farming as it stands today in Zambia is a technology of water harvesting and drought mitigation. It is adapted to arid and semi-arid areas but not suited to wetter climatic conditions, where in its present form it would lead to waterlogging. It is at odds with most of the other conservation agriculture techniques that are adapted to temperate or equatorial conditions (but not to dry climates), or to areas receiving a bimodal rain distribution.

In terms of constraints inherent in the agrarian system, we believe conservation farming can be compared with conservation agriculture in sub-Saharan Africa. In such systems, main obstacles to sustaining and widening adoption are the limited labour supply available for the farm and for communal grazing. Limiting labour available to farm activities, weeding in particular, are the traditional disaggregation of tasks and the HIV/AIDS pandemic, with over 64% of infected people in the world living in sub-Saharan Africa. Communal grazing is common throughout sub-Saharan Africa and constitutes a major problem in trying to keep soil covered, under conservation agriculture. This problem is paramount, particularly where agricultural productivity is low and climatic risk is high, where farmers capitalize on livestock (cattle mainly) and frequently overgraze.

Time is a major deterring factor in efforts to diffuse and adapt conservation farming. The technique requires medium- to long-term investment, especially in terms of labour. Conservation farming implies quality training of smallholders, careful monitoring of the system for several years, and maybe economic support of adopters to share the risk of converting land and practices. Therefore, the benefits of conservation farming must also be rigorously demonstrated. Lacking at present are tangible data on the benefits, as shown in impact assessments using control groups.

Profitability in the sense of return to land and return to labour should not be the only criterion such impact assessments use, as criteria other than maximizing profit might be of greater importance for smallholders being urged to adopt a given technique. A more flexible approach in developing and diffusing conservation farming may help overcome existing problems and lead to innovative cropping systems emerging that are able to meet the needs of diverse types of smallholders. Doing this would in turn make it possible to adopt conservation agriculture technologies of various kinds on a wider and more sustainable way throughout Zambia.

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## Appendix 1 Fast-track technologies

- Do not burn residue.
- Dig or rip accurately spaced and permanent planting holes or furrows across the prevailing slope.
- Hoe farmers: use Teren rope to mark out planting basins spaced at 90 cm x 70 cm.
- Ox farmers: use the Chaka tine and the Magoye furrower in the dry season to rip and open permanently positioned planting furrows spaced at 90 cm.
- Complete all land preparation before the onset of the rains.
- Apply and incorporate measured amount of manure or basal fertilizer in the planting holes or rip lines for cereal and cash crops in accordance with agronomic recommendations.
- Hoe farmers: use fertilizer cups.
- Plant three-course rotation with 30% of cropped area planted to legumes.
- Plant cereals and cotton at onset of the first heavy rains.
- Complete planting of all crops before 7 December.
- Plant seed accurately and rapidly to achieve even emergence and optimal population.
- Dig interrow potholes to capture moisture in season of poor rain distribution.
- Apply measured amount of nitrogen as topdressing on maize.
- Weed early and continuously to avoid competition and seeding of weeds.
- Plant 0.25-lima plot of *Tephrosia* to provide source of pesticide for stored grains.
- Plant cover crops, which include a legume.

## Appendix 2 Summary of conservation farming tillage inputs and yields, based on a plot of 1 lima (0.25 ha)

Inputs	Conventional	Basins	Ripping	Muyamba pits	Trenches
Seed rate	11,000–13,000 seeds (5 kg)	16,000 seeds (6–7 kg)	12,000 seeds (4.5–5 kg)	11,000 seeds (4–5.5 kg)	14,500 seeds (5.5–6.5 kg)
Land preparation	21 person-days	11 person-days	1 person-day	22 person-days	8.5 person-days
Number per lima	—	4000 (basins)	67 (lines)	538 (pits)	66 (trenches)
Plant population (no.)	11,000	12,000	11,200	10,760	14,271
Fertilizer rate	50 kg basal 50 kg topdress	80 kg basal 52 kg topdress	56 kg basal 34 kg topdress	—	—
Manure (tonnes)	—	4	3.5	1.0	4.7
Weeding (person-days)	17	17	9	4	5
Harvesting	2 person-days	2 person-days	2 person-days	2 person-days	2.5 person-days
Yields (50-kg bags)	22	30	27	36	35
Spacing	90 cm x 70 cm	90 cm x 70 cm	75 cm x 25 cm	20 plants/pit	75 cm x 70 cm
Soil fertility improvement	Liming	Intercropping • cover crop • mulching • compost • liming • legume shrubs	Intercropping • cover crop • mulching • compost • liming • legume shrubs	Intercropping • cover crop • mulching • compost • liming • legume shrubs	Intercropping • cover crop • mulching • compost • liming • legume shrubs



## 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.



*A participatory rural appraisal workshop in Monze during the case study*



*Group discussion in Monze during the case study*



*In the Monze–Choma area, new farm enterprises include fish farming ...*



*... and mushroom growing*



*Preparation of permanent planting basins for the 2006/07 season in Monze*



*The Magoye ripper with extended wings*



*Ripped lines*



*Intensive tillage contrary to conservation agriculture practice*



*The taproot bent within 20 cm of soil depth is evidence of plough pan*



*Healthy maize plants in a Muyamba pit*



*Fertility trenches ready for planting*



*A local man-pulled adaptation of the ripper*



*Good crop residue management on a ripped field. Increased humus was perceived in this particular field*



*Groundnuts and sunn hemp in rotation*





*Demonstration of the Zamwipe*



*A good Dolichos lablab cover*