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Conservation agriculture as a labour saving practice for vulnerable households

Suitability of Reduced Tillage and Cover Crops for Households under Labour Stress in Babati and Karatu Districts, Northern Tanzania

CONSERVATION AGRICULTURE AS A LABOUR SAVING PRACTICE FOR VULNERABLE HOUSEHOLDS

A Study of the Suitability of Reduced Tillage and Cover Crops for Households under Labour Stress in Babati and Karatu Districts, Northern Tanzania

2004

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A Joint Study by:
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LIST OF COVER PHOTOGRAPHS
Large photograph
Field day demonstration of reduced tillage and cover crops, Karatu District

Small photographs (from left)
Examining animal drawn no-tillage planter, Karatu District
Farmer in bean field with reduced tillage and cover crops, Karatu District
Farmers demonstrating hand jab planter, Karatu District
Farmer with child in front of her maize field, Babati district

Foreword

The availability of farm power is central to the success of initiatives to increase food production. It determines, in part, the area under cultivation, the timeliness of operations, the effective utilization of other inputs and ultimately, the productivity of the system.

One potential pathway for reducing the labour and farm power demand for small-scale agricultural production systems could be a shift from conventional farming practices (such as land clearance, ploughing, planting and hand weeding by hoe) to more innovative practices that make use of less labour. Tools and implements such as the jab planter and the animal drawn ripper or no-tillage planter, in combination with agronomic practices that have the potential to suppress weeds through soil cover and the introduction of cover crops, form a set of possibilities.

This working paper reports on the second component of a joint IFAD/FAO study, funded by the Government of Japan, titled ‘Improving Women’s Access to Labour Saving Technologies and Practices in Sub-Saharan Africa’. The study was instigated by the Gender Programme of the Eastern and Southern Africa Division of the International Fund for Agricultural Development (IFAD) and follows a previous joint IFAD/FAO study in 1997 focusing on the agricultural implements used by women farmers in sub-Saharan Africa. Both IFAD and the Agricultural and Food Engineering Technology Service (AGST) of FAO are increasingly concerned about the shrinking farm power and labour base in rural Africa and this opportunity to pool expertise and collaborate in a major study of this nature has been timely.

The results of the study provide initial indications that a fundamental change in agricultural practices towards reduced or minimum tillage combined with cover crops can be followed by households having a low asset base. Such vulnerable households must, however, be provided with adequate technical assistance, training and institutional support.

It is pleasing to note that the German Government has agreed to finance an FAO government cooperative regional programme for Tanzania and Kenya in order to build on the promising results that this pilot study achieved. The project titled ‘Conservation Agriculture for Sustainable Agriculture and Rural Development’ intends to apply the conservation agriculture concept in combination with the Farmer Field School methodology that is supported in both countries through an IFAD-Technical Assistance Grant.

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LIST OF ABBREVIATIONS

ACT	Africa Conservation Tillage Network
AGST	Agricultural and Food Engineering Technologies Service (FAO)
ARC	Agricultural Research Council, South Africa
B	Babati District
CA	Conservation Agriculture
CAMARTEC	Centre for Agricultural Mechanization and Rural Technology
CIRAD	Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement
CTP	Conservation Tillage Project
DALDO	District Agriculture and Livestock Development Officer
DAP	Draught Animal Power
DCM	Direct sowing, Mulch-based systems and Conservation agriculture
FARMESA	Farm Level Applied Research Methods in Eastern and Southern Africa
FHH	Female-Headed Household
FYM	Farmyard Manure
GTZ	Deutsche Gesellschaft fur Technische Zusammenarbeit GmbH
HH	Household
IGA	Income Generating Activity
K	Karatu District
LAMP	Land Management Programme
masl	metres above sea level
MHH	Male-Headed Household
NT	No-Till
RELMA	Regional Land Management Unit
RTCC	Reduced Tillage and Cover Crops
SARI	Selian Agricultural Research Institute
SCAPA	Soil Conservation and Agroforestry Programme in Arusha
SFI	Soil Fertility Initiative
TCP	Technical Cooperation Programme
TEMDO	Tanzania Engineering and Manufacturing Design Organization
TFA	Tanzania Farmers' Association
TFSC	Tanzania Farmers' Service Centre
ZFU	Zimbabwe Farmers' Union

UNITS OF MEASUREMENT

1 acre = 0.41 ha

1 ha = 2.47 acres

Currency: in January 2003: US$ 1 = Tshs 980

EXECUTIVE SUMMARY

Conservation agriculture is frequently cited as having labour saving properties and as a potential solution to farm power shortages suitable in households under labour stress. However, its suitability for use by vulnerable households in sub-Saharan Africa has yet to be examined from technical, economic and social perspectives. Its adoption requires a significant change in farming practices and the use of specialist equipment, as well as a fundamental change in mindset towards cultivation practices.

The interest in fostering the adoption of conservation agriculture in sub-Saharan Africa is the potential to address three areas of crucial importance to smallholder farmers:

- demand on household labour: HIV/AIDS and other diseases, such as malaria, as well as urban migration and education are reducing the labour availability in rural households and increasing the burden of labour-intensive activities on women and children. Conservation agriculture technologies could reduce labour requirements especially in peak seasons for land preparation and weeding.
- food security: conservation agriculture can potentially contribute to household food security by making more efficient use of rainwater and by increasing soil fertility through the introduction of nitrogen-fixing cover crops.
- household incomes: conservation agriculture could possibly reduce expenditure on hiring farm power services and purchasing fertilizer, whilst generating additional revenue through the production of fodder and cash cover crops.

The specific objectives of this study were twofold: to determine the extent to which conservation farming practices are labour saving, and their suitability for use by vulnerable households. The topic is an important area of interest in IFAD and FAO and the findings reported below contribute to the ongoing discussions and debate.

Conservation agriculture initiatives in Karatu and Babati Districts

The study was conducted in four communities in two districts in Northern Tanzania. The two districts have had varied experiences with regard to the introduction of conservation agriculture, although both originated from concerns about the impact of conventional tillage practices on land degradation. Both districts commenced with sub-soiling in the latter part of the 1990s. In Karatu this was followed by the introduction of cover crops while Babati placed more emphasis on reduced tillage systems. Key stakeholders have played a major role in driving these initiatives forward: Selian Agricultural Research Institute (SARI) and Tanzania Farmers' Service Centre (TFSC) in Karatu, and the Land Management Programme (LAMP) together with Soil Conservation and Agroforestry Programme in Arusha (SCAPA).

Field trials of reduced tillage and cover crops

For the purposes of this study, with its focus on vulnerable households, it was decided to concentrate on two principal components within conservation agriculture, namely reduced tillage and cover crops (RTCC). Although this falls short of the integrated approach of conservation agriculture (with the simultaneous practice of permanent soil cover, minimal soil disturbance and crop rotations), each element represents a step towards conservation agriculture. There were two aspects to the study: on-farm field trials to generate labour and other input data associated with RTCC in comparison to conventional cultivation systems, and a qualitative review of farmers' reactions to conservation tillage equipment and practices.

(i) Saving labour

The results below should be taken as indicative of potential trends since they are based on a small sample (27 plots) and one season. Nevertheless, they suggest that it is possible to make significant savings in labour inputs with RTCC technologies and practices. Not only does conservation tillage equipment enable particular tasks to be completed in a shorter time than the conventional method but it also requires fewer people to operate and fewer draught animals.

Opportunities for saving time and labour differ between household types and their conventional cultivation system. Greater benefits are reaped when more elements of RTCC are utilised

together rather than in piecemeal manner. Labour savings per cropping season due to the use of RTCC in comparison to conventional cultivation methods were found as follows:

- *hoe cultivators*: reductions of 60% when crop residues were slashed and left in the field (with one herbicide application), seeds were planted with the jab planter, and weeds removed manually;
- *DAP users*: savings of 75% when crop residues were crushed with the DAP knife roller (and one application of herbicide), seeds were planted with the DAP no-till planter, and weeds removed manually;
- *DAP users*: savings of 50% when crop residues were slashed and left in the field (with one herbicide application), seeds were planted using the DAP ripper with planter attachment, and weeds removed manually;
- *tractor users*: reductions of 75% when sub-soiling by tractor was followed by the DAP ripper with planter attachment (rather than conventional ploughing by DAP).

In many instances, who benefits from labour saving associated with RTCC is household-specific. In hoe and DAP households, the household head (female or male) tends to take the lead in many farm activities, whereas richer households tend to use hired male labourers. For some activities, gender roles take precedence over household type. Thus men benefit from time saved associated with using DAP or tractors more efficiently; women benefit from DAP-related technologies which reduce planting activities (such as the no-till planter or the ripper planter); and women also benefit from any reduction in the time spent weeding.

(ii) Economic analysis

The results from the economic analysis were varied and require data spanning several seasons in order to be interpreted with confidence. Nevertheless, farmers practising RTCC achieved results which were generally comparable to conventional systems. The highest gross margins were generated by farmers using tractors, either under conventional tillage or with RTCC (sub-soiling followed by the DAP ripper with planter attachment).

The RTCC cultivation systems reduced the labour component of the farm power costs by substituting non-labour farm power inputs (draught animals or tractors) for labour. However, the non-labour systems tended to be expensive, particularly in Babati when farmers follow the first DAP ripping or tractor sub-soiling by ploughing with DAP. It is only when RTCC requires minimal inputs of non-labour inputs that RTCC becomes cost-effective as well as labour saving. The change in the composition of farm power costs has particular implications for the affordability of RTCC for poorer households.

The hoe and some conventional DAP cultivators generated returns to labour (gross margins per workday) which were slightly higher than the average daily wage rate of Tsh 1000. The returns to labour under RTCC in the hand system using the jab planter were on a par with the conventional systems. However, the returns to labour improved significantly with the use of DAP and RTCC. While the DAP ripper and ripper planter achieved 2.5 times the returns of the hoe cultivator in Babati, the conventional DAP realised three times the return of the hoe cultivators in Karatu. The no-till DAP increased the returns to labour tenfold.

(iii) Farmers' evaluation

The jab planter and DAP no-till planter were rated highly due to their labour saving attributes, ease of use (women particularly appreciated not having to bend over to plant), and ability to penetrate trash. However, both were perceived to be expensive in comparison to conventional tillage implements. The DAP ripper was appreciated for saving time during land preparation and planting, but, in the absence of herbicide use, ripping was often preceded by ploughing as a weed control measure. A few technical problems were encountered and some required a learning period to become familiar with the equipment (jab planter and DAP knife roller). Several farmers continued to use conservation tillage equipment in the following season.

Lablab was the preferred cover crop offering economic, weeding and soil quality benefits. Mucuna was also rated highly but has fewer food and market opportunities. Crops which are traditionally inter-cropped with maize were also rated highly: pumpkins and sweet potatoes for their high economic value, and sunflowers and pigeon peas for protecting the soil from grazing livestock. All farmers participating in the study planted cover crops the following season. This was the most widely adopted aspect of RTCC since it offered the most flexibility to adapt to meet farmers' livelihoods needs.

Suitability of RTCC for Vulnerable Households

The quantitative analysis demonstrated that most RTCC systems offer the potential of substantial labour savings and generate returns which are at least comparable to the conventional cultivation systems. Hence the risks associated with adopting RTCC are threefold: the impact on workloads, affordability, and implications for the broader livelihood system.

(i) Workloads

The introduction of a new RTCC technology or practice does not necessarily save labour in the first season. Additional inputs of time may be required to establish a cover crop, or learn how to use the technology effectively. The extent to which this has an implication for a household depends on its sources of labour. Very poor and poor households meet most of their labour inputs from household labour, supplemented by reciprocal labour. Hence they would bear the burden of adjusting to the new technology or practice (as experienced by female-headed households using the jab planter). In contrast, rich households make extensive use of hired labour.

(ii) Affordability

Poorer households typically own farm tool assets worth Tsh 7500 (US$ 7.50). During times of hardship, they postpone or defer their purchase of replacement equipment and borrow from others, if possible. Hence, they are sensitive to any new technology or practice which requires an expenditure of cash and would struggle to purchase a jab planter which is ten times more expensive than the cheapest hoe. Growing cover crops may also be difficult if they need to be crushed in the field before the next season. Whilst the DAP knife roller and herbicide represent a very time-efficient way of dealing with cover crops and crop residues, they also require a cash outlay or payment in kind.

While the less poor households can afford to purchase the jab planter, they usually prepare the land and plant crops by means other than the hoe. Hence the technology is not perceived to be relevant for their cultivation system. However, it may have a place in these households as a labour saving tool for inter-row planting.

Within the DAP system, the ripper is within the expenditure envelop of DAP owners as an add-on to an existing plough beam. However, other items, such as the knife roller, no-till planter and the ripper planter are expensive (ranging from Tsh 75,000 – 300,000; US$ 75 – 300) and would represent a significant additional investment to the existing inventory of DAP owners (valued at Tsh 110,000; US$ 110 in total – excluding the oxen). An alternative to purchasing equipment is to hire the services of others. Many of the middle wealth and richer households regularly hire labour and other sources of farm power. Hence it would be relatively easy, and even cost-efficient, for this group to switch from conventional cultivation systems to RTCC through conservation tillage hire services.

(iii) Implications for livelihood system

Several aspects of the conventional farming system pose challenges to the adoption of RTCC. First, there is a tradition of free grazing by livestock on crop residues by livestock and it is likely that this practice would increase if cover crops and crop residues are retained in the field as a means of soil cover. Second, some of the poorer households look after livestock from richer households in return for milk and manure. Although cover crops may compromise the practice of free grazing, they can be partly harvested for dry season fodder. Third, the land cultivated by poor households may be particularly vulnerable to encroachment. Land rights are weak and the poorest farmers reported that it is difficult for them to claim their land rights because the process is cumbersome and the outcome uncertain. Four, if RTCC is widely adopted in a community, it may significantly reduce the opportunities for poorer households to engage in casual labouring.

(iv) Reaction of vulnerable households

The poor FHHs who participated in the study were among the most enthusiastic participants. They were keen to overcome their labour constraints. They were already practising reduced tillage through poverty (planting in hand-dug basins) and recognised that some of the crops they inter-cropped with maize had weed-suppressing qualities (pumpkins and sweet potatoes), as well as producing food. Even though they struggled to master the jab planter, they welcomed the tool and perceived it to be a sign of progression from the hand hoe. These farmers tended not to belong to organizations and had little contact with the extension services. This study presented an opportunity for researchers and extension staff to interact with these farmers on a regular basis and, as a result, the self-confidence of these farmers increased and they gained greater respect in the community.

Conclusions and future activities

Land degradation has played a crucial role in the two study districts in sparking an interest in elements of conservation agriculture. However, it may take the impact of HIV/AIDS and severe labour shortages to act as the catalyst for change, propelling African smallholders down the path of reduced tillage and cover crops, towards conservation agriculture.

RTCC would appear to be an appropriate path to follow, offering the potential of substantial labour savings and generating returns which are at least comparable to the conventional cultivation systems, in terms of gross margin per workday or yield per workday. Moreover, on the basis of the reaction of households participating in the study, it is a path which vulnerable households are willing to take.

In order to move conservation agriculture activities forward in the study districts, two groups of activities have been identified:

- to extend the use of RTCC in Northern Tanzania: by appraising existing technologies under local conditions and improve their suitability; validating a multipurpose conservation agriculture cropping system; and evaluating the integration of livestock into RTCC systems; and
- to reach out to vulnerable households: by encouraging extension and research services to include vulnerable households within their outreach activities; developing low, cost, low external input, manual conservation agriculture systems; underwriting the risk facing adopters during their learning period; forming user groups to purchase and share conservation tillage equipment; and linking with other initiatives which are enhancing rural livelihoods and would provide an entry point for introducing labour saving technologies and practices based on RTCC.

If these actions are successful, additional activities will be required in order to go to scale:

- to further strengthen the enabling environment: through raising awareness about the potential benefits of RTCC among stakeholders; increasing the understanding about differing opportunities to promote RTCC depending on the household context; strengthening local governance systems to address land tenure, user rights and livestock grazing conflicts; strengthening local institutions and their linkages in the RTCC innovation system; and supporting farmer-to-farmer exchange; and
- to improve access to RTCC inputs: through supporting local manufacture of conservation tillage equipment; facilitating its purchase by user groups; supporting the formation of reduced tillage-DAP hire services; establishing farmers to multiple seeds of cover crops; and promoting value adding activities for cover crops.

1. INTRODUCTION

1.1 Background

IFAD's Gender Strengthening Programme in Southern and Eastern Africa secured funding from the Government of Japan to undertake a study entitled 'Improving Women's Access to Labour Saving Technologies and Practices in Sub-Saharan Africa'. The study is being undertaken jointly between the Gender Strengthening Programme of IFAD and FAO's Agricultural and Food Engineering Technologies Service (AGST). The study follows on from an earlier collaborative venture which focused on agricultural implements used by women farmers in sub-Saharan Africa (IFAD/FAO, 1997).

The purpose of the overall study is threefold:

- to identify labour/power shortages arising in rural communities and households (in particular due the effects of HIV/AIDS) and their existing coping strategies;
- to identify how labour saving technologies and practices can assist in overcoming these shortages; and
- to identify the key factors which need to be in place in order to improve the adoption and sustained use of labour saving technologies and practices by poor rural women.

The overall study has three components: a distance survey of IFAD-supported and FAO projects and programmes in sub-Saharan Africa; and in-country studies undertaken in Kenya and Tanzania. This working paper reports on the findings from the second in-country study conducted in Tanzania from October 2002 to July 2003[1].

1.2 Urgent Need to Address Labour Constraints in Sub-Saharan Africa

At present it is estimated that 65% of land in sub-Saharan Africa is prepared by hand power. Draught animal traction plays significant roles within certain farming systems, such as the maize mixed cereal systems of eastern and southern Africa (preparing 25% of land within SSA). Tractors only make a minor contribution to land preparation at present (estimated at 10% of harvested area). A recent study by FAO's Agricultural and Food Engineering Technologies Service (FAO, 2003) projected that, unless there is change, humans and draught animal power (DAP) will continue to be the main sources of power for the foreseeable future in many countries in the region.

Land clearance, land preparation and weeding are cited in both the distance survey and the fieldwork in western Kenya as some of the most onerous tasks performed in sub-Saharan Africa. Most of the activities are performed by hand using a basic range of farm tools, such as hoes, pangas, slashers and axes. Land preparation using a hoe is very labourious and time consuming. Weeding is a critical activity and a major determinant of final yields. Draught animals ease the burden of land preparation but their use is almost exclusively confined to primary tillage and transport in much of the region. Factors that reduce the availability of farm power from any source – be it humans, draught animals or tractors – threaten the viability of rural livelihoods. Labour and power shortages at the household level have a dramatic impact on the area cultivated, the amount produced and household food security. Many households respond to their shortage of farm power by scaling down their activities and reducing the area under cultivation or growing a limited range of crops. They struggle to keep pace with the seasonal calendar which results in taking short cuts in one season (for example, reducing soil conservation activities), with adverse knock-on effects in the next.

Thus human power is a critical element within the production process, both in terms of its availability and productivity. However, both variables are compromised through poor nutrition, illness and death, lack of interest in subsistence agriculture, competing claims on time for labour intensive household tasks, and the drift away from the land in search of alternative livelihoods.

[1] The study team consisted of Clare Bishop-Sambrook (agricultural economist and team leader, IFAD consultant); Josef Kienzle (agricultural engineer and study coordinator, FAO AGST); Wilfred Mariki (agronomist, SARI, Arusha; IFAD consultant); Marietha Owenya (socio economist, SARI, Arusha; IFAD consultant); and Fatima Ribeiro (conservation agriculture specialist and facilitator of the Direct sowing, Mulch-based systems and Conservation agriculture (DCM) global programme; IFAD consultant).

1.3 Findings from Distance Survey and Kenyan Study

The distance survey, covering 23 projects and 13 countries, highlighted the emerging crisis in the composition of the agricultural labour force, becoming increasingly characterised by the elderly, female-headed households, and the very young (including orphans). The availability of labour in rural communities is being threatened by ill health and death – with HIV/AIDS hitting people in their economic prime; rural-urban migration attracting the able bodied and usually men; and education drawing young people away from farm work. The survey found that various strategies are used to overcome some of the labour and power shortages. Those who are better off or have access to non-farm sources of income or remittances, hire additional power (particularly labour) to assist with key farm operations. Many households circumvent the need for cash payment by working together in informal groups and exchanging labour, or making the payment in kind. Households access labour saving technologies through borrowing from neighbours, sharing with others, or joining groups. Some households buy cheap quality tools or use credit to purchase new tools. Many households have modified their traditional practices to minimise power requirements for land preparation and livestock rearing.

The fieldwork in Kenya complemented the distance survey with an in-depth study of labour constraints in four farming communities in Busia and Bondo Districts, Western Kenya (Bishop-Sambrook, 2003). The area is particularly susceptible to farm power shortages as a result of HIV/AIDS prevalence rates well above the national average, high levels of out-migration, the decimation of draught animals by disease, and the collapse of government-operated tractor hire services. The fieldwork focused on identifying the principal labour and power constraints faced by various groups within the community and gender-specific aspects of those constraints; examined the causes of these constraints, their impacts on livelihood systems, and coping strategies adopted by vulnerable households.

The study concluded by identifying labour saving technologies and practices which may help overcome some of these constraints and, in particular, help vulnerable households cope better with loss of labour. Many of these technologies and practices have moved beyond the research stage and are already in the public domain. Hence, the need is to facilitate the adoption of current best practice through understanding the barriers to adoption, particularly for poor and vulnerable households. The barriers faced by households headed by women, grandparents and orphans are more extreme than those facing the community at large. Their labour constraints are more severe, their asset base depleted, their cash resources stretched, and skills base limited. They are both unwilling and unable to expose their households to any risks that may threaten the very existence of their highly susceptible livelihood base. These characteristics pose additional challenges when trying to reach out to these groups.

1.4 Rationale for Focus on Conservation Agriculture

Conservation agriculture is frequently cited as having labour saving properties and a potential solution to farm power shortages suitable for use by households under labour stress. Indeed, both the distance survey and the Kenyan study found that a popular response by households to minimise their farm power requirements is to adopt reduced tillage systems, and use cover crops and mulches to suppress weeds. However, the suitability of conservation agriculture for use by vulnerable households in sub-Saharan Africa has yet to be examined from technical, economic and social perspectives. Its adoption requires a significant change in farming practices and the use of specialist equipment, as well as a fundamental change in mindset towards cultivation practices.

The interest for fostering the adoption of conservation agriculture in sub-Saharan Africa is the potential to address three areas which are of crucial importance to smallholder farmers:

- demand on household labour: HIV/AIDS and other diseases, such as malaria, as well as urban migration and education are reducing the labour availability in rural households and increasing the burden of labour-intensive activities on women and children. Conservation agriculture technologies could reduce labour requirements especially in peak seasons for land preparation and weeding.
- food security: conservation agriculture can potentially contribute to household food security by making more efficient use of rainwater and by increasing soil fertility through the introduction of nitrogen-fixing cover crops.

- household incomes: conservation agriculture could possibly reduce expenditure on hiring farm power services (labour, draught animal power (DAP), tractors) and purchasing fertilizer, whilst generating additional revenue through the production of fodder and cash cover crops.

1.5 Purpose of Tanzanian Study

The specific objectives of the Tanzanian study are twofold: to determine the extent to which conservation farming practices are labour saving, and their suitability for use by vulnerable households. The topic is an important area of interest in IFAD and FAO and the findings reported below contribute to the ongoing discussions and debate.

The findings presented in this document are based on both quantitative and qualitative data collected in four communities in Northern Tanzania. They are indicative of the key issues associated with promoting and disseminating conservation agriculture as a potential solution to labour constraints faced by vulnerable households.

The study also contributes to the Direct sowing, Mulch-based systems and Conservation agriculture (DCM) global programme. The DCM is an international initiative that aims to strengthen the capacity of key stakeholders to develop suitable DCM systems and to accelerate their wide adoption by analysing and comparing experiences from decentralised initiatives, synthesising lessons learned, and by identifying and addressing gaps.

1.6 Rationale for Site Selection

Northern Tanzania was selected as a highly suitable location for this study. The zone has already had significant exposure to aspects of conservation agriculture. In Karatu District farm trials on sub-soiling and the utilization of cover crops have been promoted through the initiatives of Selian Agricultural Research Institute (SARI) with the support of GTZ and Tanzania Farmers' Service Centre (TFSC). In Babati District a wealth of experience has been gained through the Swedish-supported Land Management Programme (LAMP) in adapting and adopting the DAP Magoye ripper and tractor-drawn equipment for reduced tillage.

1.7 Study Approach

The study focused on farmers' first hand experiences of reduced tillage and cover crops. There were two principal components: on-farm field trials to generate labour and other input data associated with conservation agriculture in comparison to conventional cultivation systems, and a qualitative review of farmers' reactions to conservation tillage equipment and practices. The fieldwork was conducted from October 2002 through to July 2003. Further details about the study methodology are described in chapter 4 with a supporting appendix.

1.8 Structure of Report

The case for conservation agriculture as a labour saving technology and practice is set out in chapter 2. Chapter 3 provides an overview of the socio-economic and agricultural characteristics of Karatu and Babati Districts. The study methodology and the livelihood characteristics of the study communities are discussed in chapter 4. The results are examined in terms of their labour-saving characteristics and impact on economic returns in chapter 5, farmers' qualitative evaluation in chapter 6, and their suitability for use by vulnerable households in chapter 7. The main conclusions and recommendations for promoting conservation agriculture for households under labour stress are presented in chapter 8.

1.9 Acknowledgements

The study team is grateful to the Government of Japan for the financial support to undertake this research. The team would also like to thank the administrations of Karatu and Babati Districts in Arusha and Manyara regions, Northern Zone and, in particular, staff from DALDO, LAMP and SARI. The full list of people met is presented in Appendix I.

The success of the study was made possible by the active participation of farmers in the fieldwork. Their on-going interest is a source of encouragement for all initiatives promoting conservation agriculture in the region.

2. THE CASE FOR CONSERVATION AGRICULTURE

This chapter describes the key characteristics of conservation agriculture and positions the concept of Reduced Tillage and Cover Crops (RTCC). Experiences of adopting conservation agriculture in Latin America and Africa are reviewed, and the extent to which it may be considered to be a labour saving technology and practice examined. Supporting data are presented in Appendix II.

2.1 Overview of Labour Saving Technologies and Practices

The various ways in which labour constraints can be addressed may be grouped hierarchically representing the degree of change they introduce into the farming and household system (Box 2.1). Some practices make minimal demands on resources and can be introduced within the existing farming system (Level 1), such as improved cultivation practices or extending the use of existing draught animals into new activities. Others require more significant changes, either in terms of injection additional resources into the system (Level 2) or developing a new system to reduce or spread the demand for labour (Level 3). Elements of conservation agriculture may be present at all three levels and this may offer some flexibility for introducing it to resource poor and vulnerable households.

Box 2.1: Options for Addressing Labour and Farm Power Constraints

Level 1: Working within the existing system and resource base

- make existing labour more productive: through better health and nutrition
- make existing tasks easier in order to reduce the demand for labour: use appropriate tools and improved practices (such as row planting, alternative planting patterns and correct spacing to make weeding easier, and inter-cropping to suppress weeds)
- make existing DAP more productive: use one animal instead of one or two pairs; use cows and donkeys; improve their nutrition and health
- extend the use of existing DAP and equipment into secondary tillage: use mouldboard plough for ridging and weeding

Level 2: Drawing additional resources into the existing system

- access additional labour and DAP on reciprocal basis
- use additional power sources: for example, hire labour, hire or purchase DAP, tractors or other mechanical means of land cultivation
- extend the use of existing power sources with new equipment: DAP planter, ridger, weeder, ripper, cart
- use herbicides
- use fuel efficient stoves and simple food processing equipment

Level 3: Developing a new system

- release labour from other time-consuming tasks to concentrate on specific activities: reduce the time spent collecting water (by harvesting roofwater) and firewood (by using woodlots or agro-forestry)
- reduce the demand for labour by changing practices (such as direct planting into crop residues/mulch with minimal land preparation, and using cover crops, mulch and crop rotations to suppress weeds)
- reduce or spread the demand for labour by substituting labour intensive crops and livestock with less intensive crops or livestock, or grow crops or raise livestock with different labour requirements
- maximise the value of labour input: farm a small area intensively, grow high value crops or livestock
- introduce new power sources for household use, such as biogas or solar energy

Source: Bishop-Sambrook, 2003

2.2 Definitions of Conservation Agriculture, Conservation Tillage and RTCC

Conservation agriculture is the *simultaneous* practice of permanent soil cover, minimal soil disturbance, and crop rotations (ACT *et al*, 2003). This is achieved by:

- maintenance of a permanent vegetative soil cover or mulch to protect the soil surface;
- direct planting without seedbed preparation through the soil cover to minimise the disturbance of the soil;
- crop residue management and weed control, to stimulate soil structure formation, improve soil fertility, and to control weeds with less dependence on herbicides; and
- pest and disease control based on Integrated Pest Management technologies and practices.

Inputs include cover crops, the use of DAP knife rollers or herbicides to crush or kill weeds and cover crops, and no-till planters. In addition to physical inputs, conservation agriculture also requires farmers to undergo ‘a drastic change in mindset’ to shift from traditional practices to the adoption of conservation agriculture (Evers and Agostini, 2001). In its entirety, conservation agriculture represents a Level 3 change. However, its components may be adopted in a piecemeal manner, at Level 1 (for example, inter-cropping cover crops) or Level 2 (using conservation tillage equipment or herbicides) (Box 2.1). These components may act as entry points for moving towards conservation agriculture.

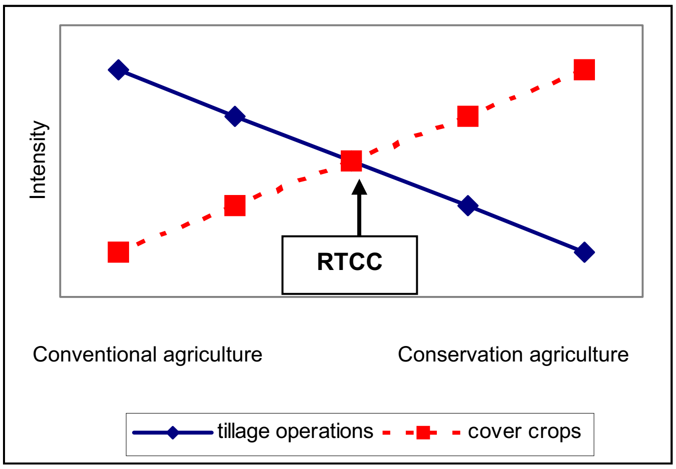
Conservation tillage is defined as ‘whatever sequence of tillage operations that reduces the losses of soil and water, when compared to conventional tillage’ (Lal, 1995 cited in Barber, 2000). The term is not synonymous with conservation agriculture since the latter is based on zero or minimal soil disturbance (FAO, 2001). Conservation tillage includes (in order of reduced soil disturbance) (Barber, 2000)[2]:

- reduced tillage: tilling the whole surface but eliminating one or more of the conventional tillage operations;
- ridge tillage: a system of annual or semi-permanent ridges and furrows, resulting in some residue cover;
- tined tillage: land is prepared with implements which do not invert the soil and which cause little compaction, resulting in a good cover of residues on the surface in excess of 30%. Equipment used include chisel plough, vibro-cultivator and DAP Magoye ripper;
- strip tillage: strips 5 – 20 cm wide are prepared to receive the seed and the intervening bands are not disturbed;
- zero tillage (or no-tillage): planting the seed into the stubble of the previous crop without any tillage or soil disturbance. Weed control relies heavily on herbicides. This approach is broadly equivalent to conservation agriculture.

A cover crop is any crop grown to provide soil cover, regardless of whether it is later incorporated into the soil (Mariki, 2003). Cover crops and green manures can be annual, biennial or perennial herbaceous plants grown in a pure or mixed stand during all or part of the year. They are grown primarily to prevent soil erosion but they also reduce soil surface temperature and water losses, add organic matter to the soil, stimulate soil life, suppress weeds and some fix nitrogen.

The relationship between conservation agriculture on the one hand (with no tillage and cover crops) and conventional tillage practices on the other (with several tillage operations and no soil cover) is reflected in Diagram 2.1. Varying degrees of conservation tillage are reflected on the x-axis, moving from reduced tillage on the left to zero tillage on the right. For the purposes of this study, with its focus on vulnerable households, it was decided to focus on the principal components of conservation agriculture in the form of Reduced Tillage and Cover Crops (RTCC).

Diagram 2.1: Context of Reduced Tillage and Cover Crops



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[2] Others identify three tillage systems: conventional tillage with less than 15% ground cover, reduced tillage (15 – 30% ground cover), and conservation tillage (more than 30% ground cover) (Steiner, 1998).

2.3 Experiences of Conservation Agriculture

The practice of zero or no-till agriculture is widespread in Latin America today, especially Brazil, Argentina and Paraguay[3]. The rate of uptake has been good, particularly in Brazil where land degradation and soil erosion have been acute and highly visible problems, convincing many farmers that change was inevitable (Pieri *et al*, 2002). Zero tillage has been facilitated by the use of systemic herbicides and tillage implements (planters and seed drills) adapted for minimum soil disturbance and crop residue cover for hand, draught animal and tractor-based systems. Farmers have been motivated to adopt zero tillage by improvements to the environment, cost and yield benefits, and particularly for small farmers, reduction of labour inputs and drudgery, and increases in the return per workday (Landers *et al*, 2002). The process has been achieved by close collaboration between farmers, researchers and extensionists[4]; on-farm trials; farmer-driven adaptations; strengthening of farmers' organizations; development of farm management skills; and private-public partnerships (Evers and Agostini, 2001). Small resource poor farmers required government assistance to organise associations and to reduce the costs and risk of change (for example, in the form of initial purchases of cover crop seeds, subsidies[5] on specialised planting or spraying equipment, and area payments). Larger (mechanised) farmers relied on private sector initiatives since zero tillage was immediately profitable (Landers *et al,* 2002).

Although parts of sub-Saharan Africa are suffering from land degradation (Box 2.2), in most parts of the region it has not yet become a principal factor in driving radical change in farming practices. In Brazil, farmers were willing to take the risk to shift to zero tillage because degradation was threatening their livelihoods and it was seen as the last option to avoid migration to urban centres (Evers and Agostini, 2001).

Box 2.2: Land Degradation and Conservation Agriculture in Africa

Increasing abuse of Africa's natural resources is propelling the countries of the continent into a spiral of decreasing food security and increasing aid dependence. To slow and reverse this spiral, the degradation and loss of Africa's agricultural resources must be urgently addressed. The adaptation and adoption of conservation tillage techniques can reduce and reverse current trends, but these options need to be identified and communicated to resource-poor farmers.

Source: Fowler and Rockstrom (2000) cited in FAO (2001)

Milestones in the promotion of conservation agriculture in Africa include the Soil Fertility Initiative launched during the World Food Summit of 1996, evolving into the Better Land Husbandry approach; 1998 workshop in Harare to discuss conservation tillage for sustainable agriculture (Benites *et al*, 1998); and the formation of the African Conservation Tillage (ACT) network[6] in 2000. There have been three distinct strands to promoting these initiatives in the smallholder sector (namely conservation tillage, herbicides and cover crops) rather than pursuing an integrated approach to conservation agriculture[7]. DAP ripping technology was introduced to Zambia during the mid 1990s and subsequently resulted in the development of the animal-drawn Magoye ripper (Stevens *et al*, 2002). DAP rippers are used in Zambia, Zimbabwe, Kenya and Tanzania. The DAP *maresha* has been adapted for ripping in Ethiopia. Indigenous minimum tillage methods include planting pits (known as *tassa* in Mali, *zai* in Burkino Faso, *demi-lune* in Niger, potholing in Zambia, the *matengo* pit system in Tanzania), and the slash and burn systems (for example, in Ghana and Tanzania (*kuberega*)) (IFAD, 1992; Shetto, 1998). Promotion of conservation tillage has often been underpinned by donor support. A recent development has been the inclusion of dry season potholing, DAP ripping and input packs as part of FAO's emergency agricultural intervention plan of action for 2003/2003 in Zambia.

[3] For a worldwide and historical perspective see Derpsch, 1998.
[4] Often a few committed individuals played a catalytic role in the innovation network, gathering the financial and human resources required for developing the technical package (Ekboir, 2001).
[5] In Parana State, most of the hand held or animal-drawn equipment was acquired with financial support from the State in the context of development programmes (mainly World Bank). In addition to overcoming economic constraints to adoption, the rationale for public subsidies was the generation of off-site environmental benefits. In some instances, the private sector (mainly tobacco companies) loaned equipment to small farmers.
[6] ACT identifies, disseminates and promotes the adaptation and adoption of resource-conserving tillage practices, initially focusing on east and southern Africa but later to cover other parts of the continent.
[7] In several countries in sub-Saharan Africa (Kenya, Zambia, South Africa, Namibia and Zimbabwe), the adoption of tractor-based conservation agriculture is higher among large scale commercial farmers, who have embraced it in the face of rising production costs (fuel and labour) and land degradation.

Initiatives to promote no-till based on herbicides and the retention of crop organic matter have been led largely by Monsanto Company (an agrochemical manufacturer), often in association with the NGO Sasakawa Global 2000 (in Burkina Faso, Ghana, Guinea, Mali, Malawi, Nigeria, Senegal, Ethiopia, Kenya, Mozambique, Uganda and Tanzania). There have been fewer initiatives to date examining the options of direct planting through cover crops (examples include Cameroon, Ghana, Madagascar, South Africa and Tanzania).

2.4 Potential for Conservation Agriculture in Africa

A review of the potential of various agro-ecological zones in Africa for adopting no-tillage was conducted in the late 1990s (Steiner, 1998). The study identified a mix of ecological and socio-economic factors which were conducive for no-tillage (Box 2.3). The regions with high ecological potential did not necessarily coincide with areas with high economic potential. Nevertheless, the initial assessment identified the most favourable conditions for no-tillage practices to be in the sub-humid and humid regions with an annual rainfall of over 1000 mm (to ensure high levels of biomass production and minimum competition from livestock for crop residues). These areas include the rainforest, the moist savannas of west Africa and part of the east African highlands. However, in much of sub-Saharan Africa, minimum tillage, rather than no-tillage, systems are considered to be more appropriate, particularly in the semi-arid and arid regions (with 300 - 800 mm annual rainfall) of west and south-eastern Africa. The greatest potential is in regions where DAP ploughing is widespread.

Box 2.3: Pre-Requisites for Adoption of Conservation Agriculture

Ecological factors	Socio-economic factors
• annual rainfall > 800 mm • bi-modal rainfall (for biomass production) • long growing season (more than 6 - 7 months (for biomass production) • soils with clay content > 20% (to reduce risk of soil compaction) • de-compaction of soil prior to shifting to conservation agriculture	• cash crops (in order to purchase inputs) • well developed rural infrastructure (inputs, credit, markets, extension services) • markets for diverse range of crops (to support crop rotation) • secure access to land • limited value on crop residues (as livestock fodder and fuel wood) • shortage of labour, high wages • access to cover crop seeds

Source: adapted from Steiner, 1998

In addition to the region-specific ecological and socio-economic factors noted in Box 2.3, there are several factors which may constrain adoption in sub-Saharan Africa generally. They include: small farm sizes (making farmers more risk averse and less willing to experiment); subsistence aspirations; lack of tenure security; difficulties in making full switches in crop rotation from cereals to legumes (due to food habits, poverty, and lack of markets); communal and traditional grazing systems; low education and literacy standards (reducing farmers' ability to become on-farm researchers); women's lack of decision-making power (even though they provide much of the agricultural labour inputs); few or poorly organized farmers' organizations; and weak marketing systems and infrastructure (Evers and Agostini, 2001). Mindset barriers include subsistence aspirations of many smallholders, a misguided commitment to ploughing (involving complete soil disturbance) due to a lack of awareness of any alternatives, and the drift away from the land particularly by the young who regard conventional agriculture as a lot of hard work and drudgery yielding low and uncertain returns (Bwalya, 2003). Indeed, a recent study in Zambia found that cotton farmers were the largest group of spontaneous adopters of conservation farming, and this was attributed to their planning skills, their personality traits suited to manage a precise farming system, and their proven willingness to work hard to manage their crops (Haggblade and Tembo, 2003).

2.5 Evidence of Labour Saving Characteristics

The existing evidence of the labour saving characteristics of conservation agriculture is inconclusive. The perception of no-till farming offering labour saving benefits is one of the principal reasons cited by farmers in South America for adopting these practices (Pieri *et al*, 2002). Studies of no-tillage systems in Brazil and Paraguay suggest savings range from 10 – 70% of the conventional labour input depending on farming system and conventional tillage practice (Table 1, Appendix II). Other benefits include a more even distribution of labour across the year, more timely operations, a reduction in drudgery, and opportunities for livelihoods diversification (Ribeiro *et al*, 2001; Pieri *et al*, 2002). Reducing the time draught animals spend in one farmer's field means there is more time available for tilling additional land (if available) or hiring out their services to others (Stevens *et al*, 2002).

This potential of conservation agriculture to save labour is recognised as a feature that may make it particularly suited to rural areas suffering from HIV/AIDS (Pieri *et al*, 2002). However, some minimum tillage methods used in sub-Saharan Africa, such as constructing semi-permanent planting basins, are more labour intensive than conventional hoeing. Nevertheless, their construction can be spread over a much longer period, including the dry season (which can result in more timely planting and greater yields) and the field preparation inputs decline in subsequent years (Diagram 1, Appendix II) (Haggblade and Tembo, 2003). Changes in draught animal power systems (from the mouldboard plough to shallow ripping) is often found to save labour. Moreover, both the manual and DAP minimum tillage systems increase labour requirements for weeding because they do not bury weeds by inverting the soil during land preparation[8].

There are various financial and labour costs incurred during the transition phase as farmers move from conventional to conservation agriculture (Box 2.4). A lack of short-term profitability may discourage farmers from adopting, unless there is a major reduction in risk (particularly with regard to yields) associated with the change in technology (Haggblade *et al*, 2003). Returns that come in gradually over time may not meet this criterion.

Box 2.4: Costs Associated with Switching from Conventional to Conservation Agriculture

Additional costs during transitional phase (years 1 – 3)
• sub-soiling to remove hardpans caused by years of hand hoeing/ploughing • purchase of new implements (hand planter, DAP implements) and training • seeds of green manure/cover crops • herbicides • liming or farmyard manure to adjust soil acidity • fertilizers when crop residues left in field until new equilibrium reached • additional labour for application of lime, FYM, weeding, constructing planting basins
Cost savings in post transition phase
• labour for land preparation • labour for weeding • herbicides (under good management, only require one pre-emergence application per season) • fertilizers once soil fertility status improved

Source: adapted from Steiner, 2002

Cover crops also potentially have a labour saving effect by smothering weeds, thereby reducing land preparation and weed control costs (Erenstein, 1999). This is particularly evident in systems where mulch is produced *in situ* (by slashing the cover crop) prior to crop establishment. The labour saving benefits are less conclusive in systems with an overlap between main and cover crop (where the cover crop is inter-cropped or relay-cropped with the main crop). Indeed, labour demands may increase if the presence of the cover crop makes the management of the main crop more cumbersome (for example, to reduce competition between the crops) and also requires establishment. An alternative to growing a separate cover crop is to mulch the previous crop residues. Although the use of crop residues saves on establishment costs, it requires the use of minimum tillage in order not to destroy the cover crop and a means of weed control (such as herbicides). However, retaining the residues as mulch also has knock-on implications for other activities which previously utilised crop residues, thereby increasing the time spent collecting fuel and fodder, or herding.

[8] In Zambia, this has resulted in the development of the weed wipe, a locally designed, relatively low cost, herbicide applicator which reduces labour inputs for weeding from about 70 to 15 workdays per hectare.

2.6 Conclusion

The existing evidence suggests there are positive farm income effects, positive secondary benefits and a reduction in farm risk arising from switching to conservation agriculture; however, *'the scarcity of information handicaps the evaluation and promotion of conservation agriculture, particularly in marginal risk-prone farming systems in Africa'* (Dixon, 2003). Thus the collection and analysis of technical and economic productivity data on conservation agriculture is a high priority and, given the challenges facing many parts of the continent from HIV/AIDS and poverty, it is highly relevant to adopt a vulnerability perspective.

3. SOCIO-ECONOMIC AND AGRICULTURAL CHARACTERISTICS OF BABATI AND KARATU DISTRICTS

This chapter sets the context for the fieldwork by providing an overview of the socio-economic and agricultural characteristics of the study districts, and the innovation system through which aspects of conservation agriculture have been introduced to the area.

3.1 District Characteristics

The study was conducted in four communities in two districts in the Northern Zone of Tanzania. The area is characteristic of the Rift valley, with mountainous areas interspersed by lakes and surrounded by open grasslands. Karatu District is situated 140 km to the west of Arusha, and is bounded in the west by Lake Eyasi and Lake Manyara in the east. Babati District lies 167 km to the south west of Arusha and is bounded in the west by Lake Manyara. The two districts share one common boundary.

Karatu has benefited from significant infrastructural improvements in the last five years with rehabilitation of the main road (ongoing), and the development of electricity and piped water supplies. In contrast, much of Babati District is without significant infrastructural support, with the exception of the growing administrative centre.

(i) Socio-economic characteristics

The Northern Zone is among the middle poor zones in the whole country. However the study area was located in the remote areas with the poorest female and male headed families. Most of the farmers contribute to the 80% of the national income live in such areas. The livelihood systems in both districts are dominated by farming and the majority of smallholder households eke out a living from subsistence agriculture (Table 3.1). Life expectancy in Karatu District has fallen from around 60 years prior to the 1990s to 47 years today (which is below the national average of 51 years).

Table 3.1: Socio-economic Characteristics of Karatu and Babati Districts

Characteristics	Karatu District, Arusha Region	Babati District, Manyara Region
Total population	186800 (2002 estimate)	351100 (2002 estimate)
Livelihoods	90% population depend on agriculture and livestock	80% population depend on subsistence agriculture
Ethnic groups	Wa-Iraqw	Iraqw (40%), Gorowa (30-35%), Mbugwe
Incidence of HIV/AIDS	Average: 17% (2002) [a] (women: 24% and men: 14%)	Average: 31% (2002) [b]

[a] *The HIV/AIDS data in Karatu were derived from testing the blood of donors and volunteers in health facilities located in Karatu and four small towns in the district (Mangola, Manyara, Oldeani and Endabash). In 2001, 662 people were tested: 18% prevalence rate (29% women and 14% men). In 2002 (January to June), 863 people were tested.*
[b] *The HIV/AIDS data in Babati were derived from testing the blood of volunteers in the hospital. In 2000, 2800 people were tested: 19% prevalence rate; 2001, 4544 people were tested: 29% prevalence rate; 2002, 2632 people were tested.*
Sources: Karatu and Babati District Offices and District Medical Offices

(ii) Traditions and norms

The Iraqw are the dominant ethnic group in both districts. They settled in the area over 200 years ago arriving from the north east (Kenya). Traditionally they were settled livestock keepers who moved into crop production in the latter part of the nineteenth century (Loiske cited by Notarp, 1998). The traditions and norms of the Iraqw are similar to those followed by other ethnic groups in Tanzania. Traditionally, the man is the most respected person in the house. He owns most of the resources and makes most of the decisions, ranging from allocating land to different crops to be grown by the family, renting land in or out, hiring farm power and equipment, purchasing and using external inputs, selling a proportion of crops after harvest, selling or slaughtering livestock, and using money earned from various sources.

The position of women is marginalised with access to, but limited control over, essential resources. They have very little opportunity to contribute to the decision making process, even when she is a major income earner or he is absent from the home. Whilst women may use equipment and tools belonging to their household, they are unable to lend them to others without their husband's approval. Women participate in meetings and development activities.

The traditions regarding decision making vary between wealth categories. Amongst the richer households in a community, men tend to act as the sole decision maker without involving other family members. Women's opportunity to participate increases as household wealth declines and families see the benefits of their participation in decision making contributing to household development. Households headed by widows, usually among the poorest in a community, enjoy considerably more freedom in decision making than married women.

Polygamy was once widely practiced and was considered to be a good indicator of wealth. However, with the decline in the profitability of agriculture, the incidence of polygamous households has also declined.

(iii) Malaria, HIV/AIDS and other illnesses

There are major health challenges facing the communities in Karatu and Babati. Babati suffers from a strain of malaria which is very aggressive. For example, in 2000 Babati District hospital treated over 81,000 out patients for malaria (accounting for 57% of all ambulant treatment) and a further 6500 in-patients (accounting for 61% of all in-patients). The figures for 2002 at Karatu District hospital were 42% and 48% respectively. In both hospitals, malaria is the predominant cause of death. Malaria represents a significant drain on scarce medical resources since treatment is available and re-infection rates are high. It also has a considerable impact on the agricultural workforce since people are weakened by a serious malaria infection for several weeks. Further details regarding the disease treatment in the two hospitals is presented in Tables 1 and 2, Appendix III.

The incidence of HIV/AIDS is difficult to ascertain with accuracy. HIV prevalence rates would appear to be higher in Babati (around 30%) than Karatu (around 20%); both are significantly higher than the national average of 8%. Indeed data derived from the routine screening of all blood donors in Babati District suggest higher prevalence rates particularly amongst younger cohorts (Table 3 in Appendix III). Little information can be derived from in-patient treatment for clinical AIDS (where someone is suffering with all the signs of full blown AIDS) because, in the absence of the possibility of curing a patient, they are usually released from hospital to die at home.

Despite the high prevalence rates, the presence of HIV/AIDS is not widely acknowledged at community level.[9] Illnesses are commonly attributed to typhoid, malaria, TB and witchcraft. It is expected that rural and urban HIV/AIDS prevalence rates are similar due to the interactions between communities[10]. A recent study (Lyimo and Owenya, 2002) in Karatu District found the impact of AIDS and other diseases resulted in the sale of assets (land, livestock, household assets and houses), a reduction in household labour, children dropping out of school, a reduction in purchased farm inputs, renting out farm land or share cropping, family members resorting to casual labouring, a decline in crop and livestock production, and a fall in household cash income (Box 3.1). Households headed by widows and the presence of orphans were becoming more numerous.

[9] A study of the youth from Mang'ola Barazani community in Karatu District found that because AIDS is a disease associated with promiscuous behaviour and shame, many patients and their families try to avoid being associated with it (Lyimo and Owenya, 2002). Once a person is known to suffer from AIDS he is automatically regarded as a dead person. In order to maintain hope and avoid shame, many patients and their families try to hide or escape the AIDS label through citing other diseases.

[10] A study of two communities in Karatu District found elements of rural populations were very mobile, with people travelling into the area to work as manual labourers (weeding, brick making, charcoal making, brewing illegal liquor) from up to 350 km, labourers on onion farms from up to 350 km, onion traders from up to 950 km, and fishermen and fish traders from up to 1500 km (Lyimo and Owenya, 2002). When there is an influx of money in a community (for example, during the onion harvest in Mang'ola), there is a lot of entertainment and excessive alcohol consumption which often results in unprotected sex. People from the community travel within the locality for water and firewood, livestock grazing, employment, and basic health and education services. They also travel much further afield (up to 200 km) for purchasing inputs, seasonal grazing, marketing, further health care and secondary education.

Box 3.1: Impact of AIDS

Once a farmer is diagnosed with AIDS, all the household income is spent on treatment, and much of the family time is spent on their care. On death, the family is often left in a destitute condition, having sold their assets to raise cash for treatment and for the burial ceremony.

Source: Lyimo and Owenya (2002)

(iv) Land tenure

During the era of low population densities, land was abundant and everyone could have access to as much land as they could cultivate. Under the traditional system of inheritance in the Iraqw tribe, the entire farm was handed over to the youngest son. Other children would be assisted in clearing new land for agricultural activities but this habit has stopped in Karatu and Babati Districts due to land scarcity, and farms are subdivided.

With the advent of *Ujamaa* (villagisation) in 1974, village governments took on the function of land allocation. The amount given per household depends on the availability of land in each district but, on average, ranges from 1.2 – 2.5 hectare (3 – 6 acres) per household. Since 1974, the majority of people (80%) access their land through the formal system, although a proportion still inherits. The law permits women to own land but many are not aware of their rights. Land that has been allocated to a man remains with his wife and children on his death.

Due to land scarcity, it is no longer possible for pastoralists to graze on unutilized land. Village governments try to balance the need for land between farmers and pastoralists and to minimise conflict by allocating areas where pastoralists can graze their livestock.

3.2 Agricultural Characteristics

There are several similarities between the farming systems in the two districts (Table 3.2). Although Babati is nearly twice the size of Karatu, both cultivate 30% of their surface area and have similar population densities (180 – 200 people per km^2 of arable land or around 60 people per km^2 of the total area). Both experience bimodal rains, which are extremely variable. They share a common farming system: Iraqw mechanised mixed farming which is characterised by mechanised and motorised cultivation of annual crops and sedentary livestock keeping with extensive free grazing (Mansoor and de Steenhuijsen Piters, 1999). Within this broad classification, there are three distinct agro-ecological zones in Karatu District and six in Babati District. The study communities are located in the midlands in Karatu, and in the semi-humid and semi-arid midlands in Babati.

Maize, inter-cropped with pigeon peas and beans, is the main cropping pattern for the long rains[11]. Single stands of beans are grown during the more uncertain short rains[12]. Wheat production is also important in the long rains in Karatu and is made more accessible for smallholder farmers by the availability of combine harvester hire services. A wide range of cash crops are grown in Babati due to the influence of altitude, topography, soils and rainfall including large-scale irrigated and mechanized sugarcane production, coffee, cotton, sunflowers and pyrethrum.

[11] Maize is planted in February, followed four weeks later by pigeon peas or beans. The maize is harvested in August and the inter-crops remain on the land until October.
[12] Beans are planted in October/November and harvested in January/February of the following year.

Table 3.2: Agricultural Characteristics of Karatu and Babati Districts

Characteristics	Karatu	Babati
Altitude (masl)	1000 – 1900 masl	950 – 2450 masl
Rainfall (annual mm)	500 – 1000 mm	500 – 1200 mm
Long rains (*masika*) Short rains (*vuli*)	March – June (peak April) October – December	February – May November – December/January (often connect to long rains)
Topography	Undulating lands	Undulating hills and mountains (part of Rift valley highlands)
Soils	Volcanic clay soils	Sandy/clay loams
Land (total area)	3201 km^2	6069 km^2
Land use	Arable: 102573 ha (30% total area) Pasture: 155800 ha (50%) Bushes and trees: 61200 ha (20%)	Arable: 180000 ha (30% total area)
Agro-ecological zones	**Highlands**: 800 mm rainfall, highest potential: agro-pastoralists; capital intensive coffee and grain production; dairy farmers; tractors used extensively with some hoeing. **Midlands**: 500 – 800 mm rainfall: agro-pastoralists; tractors, draught animals and hoe for land preparation. **Lowlands**: less than 500 mm rainfall: pastoralists using rangelands, small-scale irrigated farming (onions, rice); hire tractors for ploughing and hoe for weeding.	**Large scale mechanized sugarcane farming with irrigation and dairy cattle**: 900 – 1000 mm rainfall: 100% use tractors; all keep zero grazed cattle **Humid highlands**: 800 – 1000 mm rainfall: agro-pastoral, 80% use DAP **Semi-arid and semi-humid midlands**: 750 – 900 mm rainfall: mechanized medium to large scale mixed cropping with 90% use tractors and 10% oxen; and mechanized small scale mixed farming using tractors and DAP **Semi-arid uplands**: 600 – 800 mm rainfall: mechanized intensive mixed farming using tractors and DAP **Semi-arid lowlands**: mechanized small scale mixed farming with 90% tractor and 10% oxen
Food crops (ha) *	Maize (28,000), beans (5500), sorghum (700)	Maize, pigeon peas, millet, beans, paddy, cassava, Irish potatoes, sweet potatoes, banana
Cash crops (ha) *	Pigeon peas (6600), wheat (4100), coffee (3000), onions (2400), barley (900), finger millet (800), paddy (500), sunflower (420)	Cotton, coffee, pigeon pea, sunflower, simsim, sugarcane, groundnuts, finger millet, wheat, lablab, pyrethrum, onions
Livestock (number)	Indigenous cattle (154,000), dairy cows (2800), goats (119,000), sheep (43,000), pigs (16,000), poultry (65,000), donkeys (7400)	Cattle (224,000), goats (165,000), sheep (70,400), pigs (13,700), poultry, donkeys (9200)
Population density	57 people per km^2 of total area 182 people per km^2 of arable area	58 people per km^2 of total area 195 people per km^2 of arable area
Average area per farmer	2 ha	0.5 ha
Power source for primary tillage (% area cultivated)	Hand: 5% DAP: 25% Tractor: 70%	Hand: 10% DAP: 60% Tractors: 30%
Main cropping patterns: Long rains Short rains	 30 – 40% area under wheat; maize inter-cropped with pigeon peas, beans Beans, some short variety maize	 Maize inter-cropped with pigeon peas, beans Beans

** area planted in April 2002*
Sources: Crop and livestock data for Karatu (2002): DALDO's office
Farming systems and agro-ecological zone data for Babati: Ringo et al (2002)
Estimates of power sources: Mechanization Officers

Karatu District has largest area of land per farmer (2 ha) and the highest number of tractors in the country. Tractors have been the dominant source of power for primary tillage but their use has declined during the last decade in favour of draught animals. Average holdings are much smaller in Babati (0.5 hectare per farmer) and draught animals have long played a prominent role in primary tillage but there is very little use of DAP for weeding. Demand for tractor hire services has fallen in both Districts as hire charges have increased to cover increases in the cost of fuel, repairs and maintenance. The Government has also supported the shift to DAP partly in an attempt to reduce the use of foreign exchange. Oxen are hardy local breeds and generally four animals (two pairs) are used per plough. DAP is also used as a standby when tractors cannot get on the land during heavy rains. Households relying on hand power include the poor and very poor, and farmers with land which is unsuitable for other power sources (either very steep or stony).

Livestock systems differ across the agro-ecological zones. In Karatu, the most intensive systems based on zero grazing, cut and carry of residues, are found in the highlands while livestock are grazed extensively in the lowlands. In the midlands, the livestock migrate to the lowlands during the cropping season and return after harvest to graze on the crop residues. Although most farmers in Babati keep some livestock, differences in the grazing systems result in many conflicts. Uncontrolled grazing is a major constraint on production in the midlands even though there are by-laws which prohibit grazing in any field after harvesting a crop [13].

The main constraints within these farming systems are soil erosion, soil fertility, hardpan and surface sealing, unreliable rainfall, insecure land tenure rights, coupled with lack of access to inputs and extension services, and poor marketing (Mansoor and de Steenhuijsen Piters, 1999 and Ringo *et al*, 2002). Environmental degradation partly reflects the evolution of farming systems in the area, with bush clearing programmes to eradicate tsetse in the late 1940s and 1950s and the expansion of Iraqw agro-pastoralists into the area; villagisation which increased deforestation, the use of marginal lands, and more intensive utilisation of livestock tracks; and commercial wheat production which commenced during World War II and is associated with extensive tractor cultivation (Rohde and Hilhorst, 2001). The ability to create and maintain soil conservation measures (such as terraces, bunds and contour farming) has been compromised by a sense of insecurity regarding land tenure, share-cropping arrangements, the practice of hiring tractors, and wandering livestock. Seasonal labour constraints are becoming commonplace, particularly at weeding time, and are driving up casual labour rates.

3.3 Conservation Agriculture Initiatives and Innovation System

The two study districts have had varied experiences with regard to the introduction of conservation agriculture, although both originated from concerns about the impact of conventional agricultural practices (in particular, mechanised ploughing using DAP or tractors) on land degradation which, in turn, reduced crop yields (Box 3.2).

Box 3.2: Land Degradation due to Conventional Tillage Practices

Agricultural productivity in Tanzania is generally low being constrained by low soil fertility, erratic and unreliable rainfall, and poor production techniques. Conventional agriculture as practised in many parts of the country is characterised by *'straw burning and intensive tillage using hand hoes, ox-drawn and tractor-drawn disc ploughs and harrows. The soils are inverted, pulverized and left bare. Under the tropical intense rains, the bare soils cap or crust, reducing infiltration and increasing runoff, and hence erosion'* (page 2).

As a result of frequent ploughing and compaction caused by post harvesting grazing of crop residues, a hard pan forms under the surface through which neither roots nor rainwater can penetrate. Whilst soil conservation measures can reduce the symptoms of erosion, conservation tillage is required to restore damaged soils low in organic matter.

Source: Shetto et al, 2001

[13] If the by-laws are breached, a fine of Tsh 5000 (US$ 5) is payable. If the offender fails to pay the fine, the village extension officer assesses the damage and, if this payment is refused, the case is forwarded to the police and on to a court of law, and the offender can be sent to jail. The rationale for infringement may be that the cost of the fine is less than the value of one of the flock or herd; hence it is better to lose one animal to pay the fine than the whole flock or herd due to hunger.

Both districts commenced conservation agriculture initiatives with sub-soiling in the latter part of the 1990s. In Karatu this was followed by the introduction of cover crops while Babati placed more emphasis on reduced tillage systems using the tractor-drawn vibroflex[14], DAP ripper and manual pitting (Table 3.3).

Table 3.3: Conservation Agriculture Initiatives in Karatu and Babati Districts

	Karatu District	**Babati District**
Initial motivation to introduce conservation agriculture techniques	Low crop yields attributed to formation of hard pan	Low crop yields attributed to formation of hard pan and water stress
Lead agencies	SARI/TFSC	LAMP
Conservation agriculture techniques practised to date	Sub-soiling by tractor Cover crops (lablab and mucuna)	Sub-soiling by DAP or tractors Reduced tillage by DAP-drawn ripper or tractor-drawn vibroflex Farmyard manure applications, crop rotation and soil cover
Progression of CA	Phase I: Sub-soiling with tractor (1998): 28 free demonstration plots (under GTZ by TFSC): farmers then meant to adopt minimum tillage using chisel plough Phase II: Cover crops (introduced 1999/2000): 14 trial sites established on sub-soiled plots, reduced to 4 in 2001 Phase III: No-till and direct planting equipment (introduced 2002 short rains): jab planters, DAP knife rollers, DAP no-till planters, DAP sprayer, and tractor mounted direct seed drills	1995/96: nine on-farm demonstrations in nine villages covering five ecological zones (0.2 ha with DAP-sub-soiler and ripper and 0.2 ha tractor-drawn sub-soiler) and studied impacts on maize yields. Demonstrations continued for three years.
Training	Farmers on sub-soiling, cover crop utilisation and reduced tillage	Extension staff and farmers on use of draught animals for land preparation and use of DAP ripper. In turn farmers trained other farmers in village with technical backstopping from LAMP. After training, group receives ripper. By 2002: 80 extension and 125 farmers trained; 30 rippers distributed to groups
Dissemination	Demonstration site (2.8 ha) adjacent to monthly market, Karatu town Field days on-farm once a year Field days held at demonstration site and on-farm By 2002, over 1600 farmers exposed to conservation agriculture	Field days held on-farm
Sourcing of inputs	Tractor sub-soilers from Kenya and Brazil Conservation tillage equipment from Brazil through FAO Seeds multiplied locally	Tractor-drawn implements imported from Norway DAP implements initially imported from Zambia but now made by Nandra Engineering Works Ltd, Moshi
Distribution of inputs	Seeds and equipment through SARI and hire services through TFSC	DAP implements through Tanganyika Farmers' Association
Independent adoption	Tractor sub-soiling offered by TFSC at Tsh 45,000 per ha Adoption of cover crops (mainly lablab) (usually not on sub-soiled sites): about 250 farmers in Karatu (150 ha)	Sub-soiling commercialized in 1999 using tractor-drawn sub-soiler: farmers pay Tsh 12,500 per ha and LAMP contributes Tsh 25,000 per ha Area sub-soiled: 275 ha in 1999; 360 ha in 2000; 360 – 400 ha in 2001 Estimate 120 rippers sold privately through TFA

Source: Field data

[14] The tractor-drawn vibroflex is a ripping tool with long swinged tines.

(i) Karatu District

The lead players promoting conservation agriculture in Karatu District are the Selian Agricultural Research Institute (SARI) and Tanzania Farmers' Service Centre (TFSC)[15]. Almost 30 demonstration plots on smallholder farms were sub-soiled free of charge by TFSC (with support from GTZ). Participating farmers were expected to shift to minimum tillage using the chisel plough or ox plough, and leave crop residues on the field[16]. Cover crops were introduced following the conservation tillage workshop held in Harare in 1998 which was attended by a SARI staff member. Trials were established to examine the effects of cover crops (lablab and mucuna) on soils and yields of maize and pigeon peas[17]. Research undertaken by SARI has been strongly linked to dissemination and training. Farmer field days have been held once a year to raise awareness in the local community and distribute cover crop seeds. In addition, a large demonstration site was established next to the monthly market ground in order to stimulate interest among a much wider groups of farmers.

Results from field trials conducted between 1999 and 2002 found sub-soiled plots typically yielded 4 tons per hectares whereas plots without sub-soiling only yielded 0.75 – 1 tons per hectares (Mariki, 2003). Cover crops were found to improve yields, soil nutrient status, soil moisture, rainwater productivity, total biomass and earthworm populations. These benefits were often further enhanced if maize stovers were also left in the fields. As a result of these demonstrable benefits, cover crops have been adopted by about 250 farmers in Karatu (covering 150 ha). Some farmers have continued sub-soiling by TFSC on a private basis.

(ii) Babati District

The conservation agriculture initiatives in Babati have been lead by the Land Management Programme (LAMP), a Swedish-supported programme working with the District administration to address various aspects of land degradation[18]. Other key players are the Soil Conservation and Agroforestry Programme in Arusha (SCAPA) and Regional Land Management Unit (RELMA).

The main thrust of conservation agriculture activities has been on reduced tillage systems using DAP and tractor-based technologies. Adaptive research trials were established on-farm, with farmers committing themselves to participate in the research for three years and would be compensated for possible yield losses in the experimental plots (Jonsson *et al*, 2003). The DAP Magoye ripper and sub-soiler were introduced from Zambia and have subsequently been thoroughly integrated into the innovation system. Through the initiatives of LAMP and the District Mechanization office, the ripper is now manufactured in Moshi by Nandra Engineering and distributed through Tanzania Farmers' Association (TFA). The ripper is also made by SEAZ Agricultural Equipment Ltd based in Mbeya which specialises in DAP technology. In response to requests from farmers, the ripper wing attachments have been specifically adapted for the inter-row weeding of maize. Under the LAMP programme, rippers are given to groups of farmers once they have been trained and they keep them for free after holding demonstrations for one or two seasons. The District administration has also embraced the technology and in 2002 stated an intention to establish a ripper demonstration site in each village in the District. The favourable response to the ripper is attributed to the familiarity with the use of DAP, and the increased and more uniform yields associated with the DAP ripper[19] (Jonsson, 2003). LAMP is also addressing issues of land security which is often regarded as one of the main constraints for adopting conservation agriculture.

[15] TFSC is a private company hiring out tractor and combine harvesting services, servicing machinery, and selling agricultural machinery and implements. Reflecting its origins as a German development project, it has retained a mandate to support sustainable agricultural initiatives in the region.
[16] Similar activities have also taken place in Hanang District by SARI and TFSC.
[17] Further details about the trials and results may be found in Mariki, 2003.
[18] LAMP started as an agro-forestry project in the 1980s, initially operating only in Babati District but has subsequently broadened both its coverage (to four districts) and scope. Each district identifies activities to suit local priorities.
[19] Despite achieving slightly lower yields than the ripper, farmers ranked the hand-dug pits as the best system due to the control it gives farmers when applying fertilizer and manure.

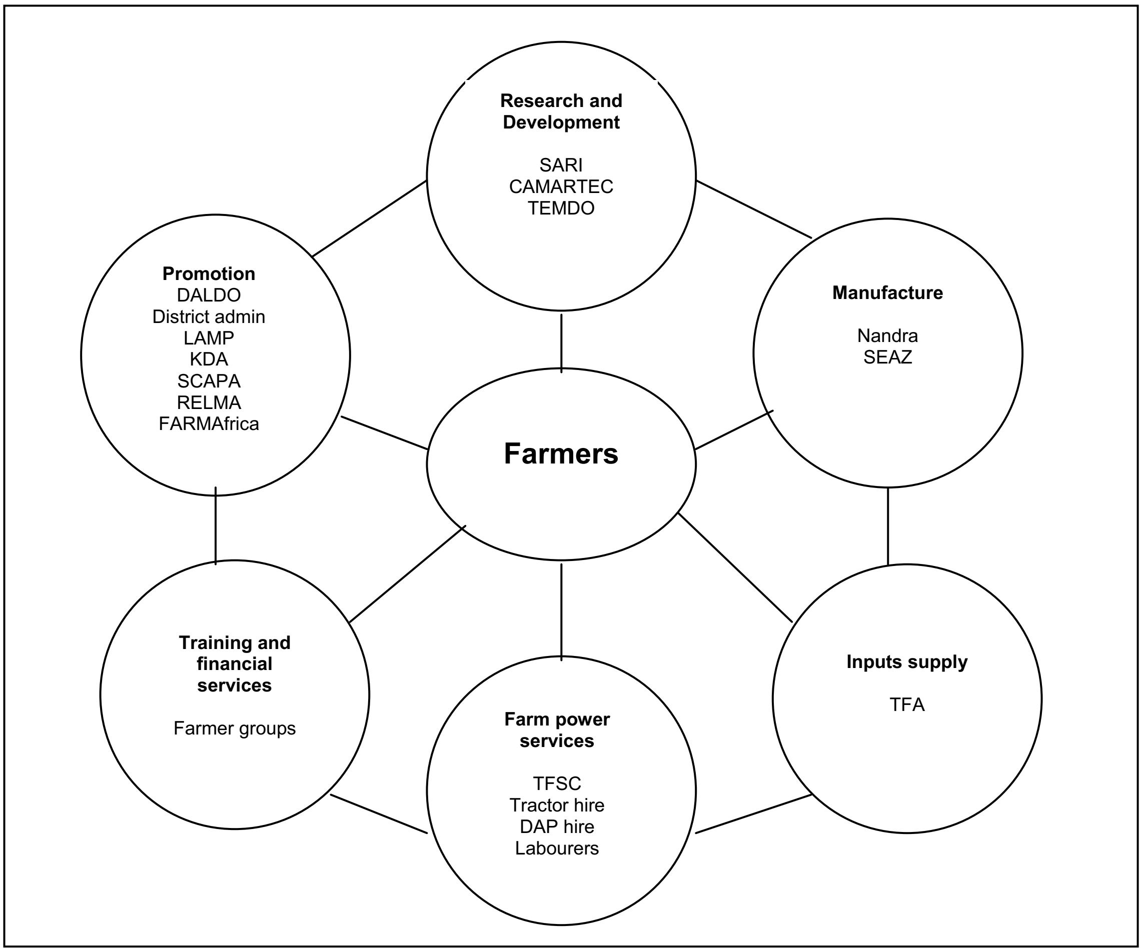
(iii) RTCC Innovation System

In addition to the pivotal roles played by SARI/TFSC and LAMP in introducing and supporting conservation agriculture initiatives in the study districts, several other organizations have contributed directly to developing the RTCC innovation system (Diagram 3.1). They embrace:

- government services including district administration, agricultural extension (specifically through the Conservation Tillage Project), SARI and applied engineering research through Centre for Agricultural Mechanization and Rural Technology (CAMARTEC) and Tanzania Engineering and Manufacturing Design Organization (TEMDO);
- NGOs supporting local development initiatives (including conservation agriculture) such as Karatu Development Association (KDA), SCAPA, RELMA and FARMAfrica;
- the private sector, ranging from farm power service providers (TFSC) and retail outlets (such as TFA), to manufacturers of no-till equipment (Nandra Engineering Works and SEAZ agricultural equipment company); and
- farmers who play a key role in on-farm trials, adopting and adapting technologies and practices, providing feedback to researchers and manufacturers, and disseminating results to other farmers.

Further details about the innovation system are presented in Appendix IV. Other organizations and activities may also provide indirect entry points for promoting conservation agriculture. For example, if the technologies are demonstrated to be labour saving, they may be used to increase the time available to participate in other income generating activities, such as dairy production (heifers or goats) or non-farm ventures that are being promoted.

Diagram 3.1: Innovation System for RTCC in Karatu and Babati Districts



4. STUDY METHODOLOGY AND STUDY COMMUNITIES

This chapter describes the methodology used for the fieldwork, briefly describing the RTCC technologies and practices which were field tested, the manner in which farmers participating in the trials were selected, and the quantitative and qualitative data collection techniques. The chapter concludes with a description of the livelihoods in the study communities.

4.1 RTCC Technologies and Practices

The core of the study was to evaluate the suitability of aspects of RTCC for use by vulnerable households. The data requirements were twofold: to conduct a quantitative assessment of the impact of RTCC on labour inputs in the farming system, together with its implication for the use of other inputs; and to undertake a qualitative assessment of farmers' reaction to RTCC once they had been exposed to conservation tillage equipment and practices for at least one cropping cycle. These data requirements were achieved through undertaking field trials with selected farmers, arranging open days for the wider community, and conducting group discussions.

Several aspects of RTCC were field tested:

- conservation tillage equipment for reducing tillage and direct planting: hand jab planter, DAP knife roller, DAP ripper and DAP planter (see Table 4.1 for further details);
- crop residues: leaving stovers and other materials in the field; and
- cover crops: inter-planting cover crops between the main crop.

In order to provide access to conservation tillage equipment, FAO through the African Conservation Tillage (ACT) network, sponsored the procurement and shipment of two containers of conservation tillage equipment to Tanzania. The consignment included various models of hand operated jab planters; DAP operated no-tillage planters, sprayers and knife rollers; and tractor operated no-till planters and knife rollers. The equipment was first used in farmers' fields during the short rains of October 2002 under this study.

During the field trials, participating farmers were loaned the conservation tillage equipment but had to pay the cost of any hired labour associated with using the equipment. For example, farmers borrowed the hand jab planter but some hired labourers to use it. DAP owners tried the DAP no-till planter and knife roller, free of charge but non-owners paid the commercial rate for hiring these services from the DAP owners. Participating farmers were also provided with 10 kg of improved varieties of beans[20]. Several farmers who left crop residues on their field received 0.5 litre of herbicide (glyphosate) but were responsible for the application during land preparation prior to planting.

[20] The strategy of providing improved varieties represented an opportunity to increase farmers' exposure to alternative varieties.

Table 4.1: Features of Conservation Tillage Equipment

Equipment	Features
DAP knife roller 	• bends over and crushes crop residues and cover crops prior to planting (which then remain on field as soil cover) • saves the removal of crop residues by hand • residues act as cover to suppress weeds • requires two draught animals and two operators • imported but could be made locally • costs Tsh 300,000 (US$ 300)
DAP direct planter 	• plant through crop residues and crop cover with no tillage • removes the need to prepare the land for planting • requires one or two draught animals and two operators • imported from Brazil • costs Tsh 120,000 (US$ 120)
DAP ripper (with option of planter attachment) (Magoye ripper) 	• cuts furrow rather than inverts soil • requires two draught animals and two operators • planter attachment places seed directly in ripper furrow • wings can be attached for ridging and weeding (reduces time by half because do both sides of row in one pass) • originally imported from Zambia, now manufactured in Moshi • ripper tine costs Tsh 60,000 (US$ 60) excludes plough beam • planter costs Tsh 75,000 (US$ 75)
Hand jab planter 	• plant through crop residues and crop cover with no tillage • removes the need to prepare the land for planting • also use to apply fertilizer • imported from Brazil; also manufactured locally (CAMARTEC) • locally made costs Tsh 10,000 (US$ 10); imported costs Tsh 15,000 (US$ 15)

4.2 Quantitative Data Collection

(i) Farmer selection

Farmers were selected purposively to represent a cross section of households in their community. Special attention was paid to ensure there was adequate representation of the more vulnerable households since they are often overlooked in efforts to promote conservation agriculture.

The method used varied between the two districts reflecting their different experiences with conservation agriculture. In Karatu, the ward extension officer approached 'ten cell' leaders (the lowest level administrative unit) for names of (a) those who were already growing, or had expressed an interest in growing, cover crops and (b) widows, particularly those who were innovative and receptive to new ideas. A cross section of farmers from these meetings was selected to participate in the study. Their household profiles were broadly representative of the whole community. In Babati District emphasis was placed on identifying farmers who were already experienced in using DAP rippers and the tractor-mounted vibroflex, complemented by other farmers who were representative of the main community.

Women and men were represented equally among the participating households (Table 4.2). However, most of the female-headed households were among the poorer households, whereas most of the male-headed households were in the middle wealth or rich categories.

Table 4.2: Distribution of Participating Households by Household Type and Wealth

Household type	Wealth category (number of households)				
	rich	middle	less poor	poor	very poor
FHH	1	1	4	-	3
MHH	3	4	-	2	-
Total	**4**	**5**	**4**	**2**	**3**

(ii) Field trials

Due to the intensity of recording labour data during the field trials, the sample was restricted to 27 plots (18 farmers): 17 plots in Karatu and 10 plots in Babati. During the study, 14 plots were managed under conventional farming methods and 13 plots were cultivated with different aspects of RTCC. The data for both sites in Karatu District and Tsamasi in Babati District relate to bean production in the short rains season (October 2002 – February 2003). The short rains failed in Singe so the data relate to maize grown in the long rains season of 2003 with some farmers inter-cropping cover crops.

Extension staff[21] were trained in collecting and recording the data. The data were entered into a spreadsheet in SARI, checked and any queries were clarified during the qualitative study held in March – April 2003. The following data were collected:

- **labour data**: Every operation which took place on the study plot was recorded throughout the short rainy season, from clearing the land of the previous crop residues and preparing the land, through to final harvest. The time spent on each activity was recorded in terms of duration, who was doing the work, the manner in which the task was performed, and date. Towards the end of the study, background information about each person working on the plots included in the study was recorded (age, sex, relationship to household, payment (if any), and reciprocal arrangements (if any)). In the analysis, the contribution of children under 16 years of age was weighted by a factor of 0.5 (FAO, 1992). Labour profiles were prepared for each plot and were aggregated to hours per hectare equivalent to facilitate comparisons between plots.
- **other inputs**: The tools and equipment used with each activity were also noted, together with the quantity and source of other of inputs (such as seeds, farmyard manure, and herbicides) including their cost if purchased.

[21] This was performed by Frank E Albert (ward extension officer, Karatu), Elley Mbise (District agricultural mechanization officer, Babati) and Mrs Adelta Macha (village extension officer, Tsamasi, Babati District).

- **plot size**: during the cropping season, each study plot was measured by the project field staff.
- **yields**: at harvest time, yields were measured by project field staff.

4.3 Qualitative Data Collection

The qualitative review was conducted in April 2003, at the end of the short rains after farmers had been exposed to RTCC for at least one season. Group discussions and semi-structured interviews were used to gather information from key informants, in particular staff from the Department of Agriculture and Livestock, village elders and administrators.

In addition to gathering the opinions of farmers' participating in the study, the views of the wider community were also sought. Two field days were held in Karatu District to demonstrate cover crops and conservation tillage equipment. The first was held at one of the participating farmer's fields in January 2003 and was attended by 53 farmers (of whom 14 were women). The second was held at the Ward Extension Office and focused on conservation tillage equipment; it was attended by 94 men and 33 women.

Details of the methods used for collecting qualitative data are presented in Appendix V. Group discussions were well attended, reflecting the high level of interest in the topic at community level. On average, women accounted for one third of the participants.

4.4 Potential Sources of Distortion

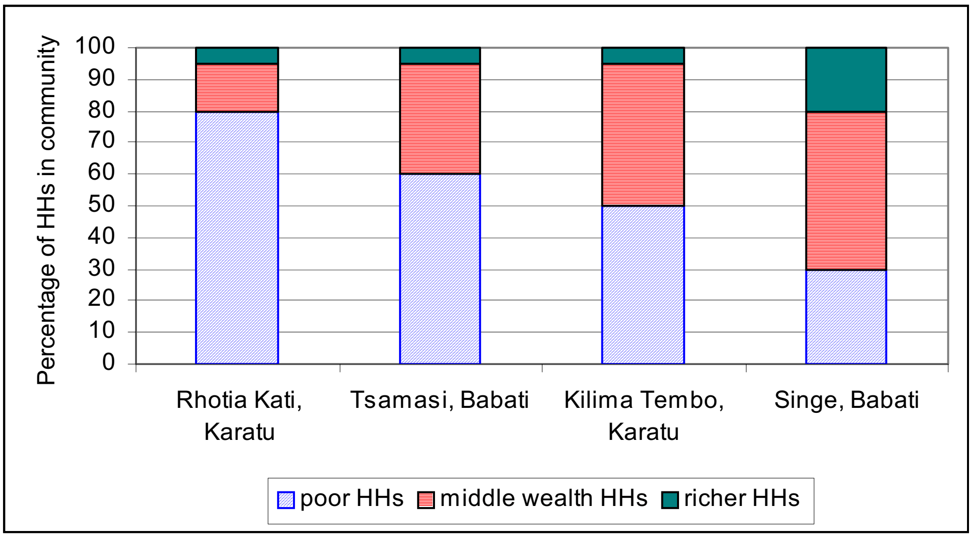
The intention of the study was to conduct the trials under conditions which were as close as possible to the reality of life facing smallholder farmers, with minimum disruption caused by the study. In the event, some plots were affected adversely by natural events, such as pests and dry weather, which influenced the data. In addition, in a small study which was only conducted for one season, there are several potential sources of distortion which may also influence the results, including:

- farmers spent more time than normal working on their plots because they wanted to achieve the best results for the study;
- many of the farmers were not familiar with the conservation tillage equipment; hence the times for each activity may have been longer than if they were familiar with their use;
- the sample size was small;
- measurements of plot size may have been inaccurate;
- yield measurements may have been inaccurate;
- scaling up the results from small areas to one hectare equivalents may have magnified any errors in recording;
- a bumper harvest of beans in the short rains season may have made it difficult to detect any impact of different tillage systems on yields;
- farmers were provided with inputs (improved varieties of beans and herbicides) which they would not otherwise use;
- farmers in one community were urged by the church to inter-crop maize with the beans because good rains were forecast;
- the activities and yields of several farmers were adversely influenced by natural events, including a short dry spell after the first rains, pest attack and heavy weed infestation;
- the estimates of the average length of the working day for different activities were inaccurate;
- the recall time for labour data was kept to a minimum by using local extension staff to gather information on a very regular basis (visiting each farmer several times a week); nevertheless, there may have been some errors in recall;
- since the data were based only on one season, no account was taken of medium term benefits (such as the value of the cover crop, improved yields and further reduction in labour inputs).

4.5 Rural Livelihoods in Study Communities

The final section provides an overview of livelihoods in the four study communities. In three communities, the majority of households are perceived to be poor, particularly in Rhotia Kati (Diagram 4.1). On average, about 5% of households in each community are considered to be rich with the exception of Singe where 20% are better off. The main characteristics are discussed below and further details may be found in Appendix III.

Diagram 4.1: Distribution of Households by Wealth in Study Communities



(i) Kilima Tembo and Rhotia Kati, Karatu District

In Kilima Tembo the richer households cultivate more than 4 hectare (10 acres) and the middle wealth, 1.2 – 4 hectare (3 – 10 acres); the areas cultivated are slightly less in Rhotia Kati. The majority of the richer households and many of the middle wealth households in both communities hire tractors for land preparation. There has been a switch in favour of draught animals. In Rhotia Kati farmers were concerned that the tractors were destroying their soils and forming hardpans whereas the use of DAP was seen to increase yields. They also own DAP and hire labour for weeding and harvesting. If they do not have sufficient cash to hire tractors they surrender a proportion of the land which had been prepared (for example, 50%) to the tractor owner. Combine harvesters are hired for harvesting wheat in Rhotia Kati.

The poorest households are dependent on others in the community for their livelihood, working as casual labourers for other farmers, renting out some of their land to raise cash, and looking after the cattle of the richer households. They may own a few chicken or goats. In Kilima Tembo, the fact that these households only sell their crops in the village is an indication of their poverty.

In Rhotia Kati poor households with only one ox join with others to establish ploughing teams. Some of those without access to DAP plant in holes to minimise the labour input for land preparation. In Kilima Tembo the poor households are entirely dependent upon hand power. The association between female-headed households (estimated to account for 30% of the total households) and poverty is most marked in Kilima Tembo where they are significantly over represented amongst the poorer households.

Groups include Kilima Tembo Women group (principally involved in growing and selling wheat but also sensitises members about environmental conservation, sanitation, child care and nutrition) and a maize production group (for accessing inputs on credit).

(ii) Tsamasi and Singe, Babati District

Tsamasi is a small scattered community of 650 households, situated 30 km to the south east of Babati (Table 3, Appendix VI). It lies at the head of a valley, 3 km from the nearest trading centre Gallapo, and access along the gravel road is difficult during the rainy season. Singe (350 households) lies adjacent to the main road 12 km due south of Babati (Table 4, Appendix VI). The two sites are located in the semi-humid and semi-arid Midlands, with an average rainfall ranging from 750 – 900 mm per year. Although the main farming system in this region is classified as mechanized small-scale mixed farming, during the field study it was observed that the hand hoe and DAP implements are as important as tractors for agricultural operations.

The livelihood profiles for the three wealth categories in both communities are similar to those encountered in Karatu. The poorer households struggle to make a living, principally through casual labouring, augmented with petty sales of crops and small livestock. They also look after the livestock of other wealth groups. Poor households cultivate less than 1 hectare (2.5 acres). In Tsamasi, those who do not have their own land rent it in from the middle wealth households in return for labour. They rarely purchase inputs and make limited use of DAP (hiring in Tsamasi and joining up with other DAP owners in Singe).

The wealthier households hire tractors, the majority own DAP, and many hire labour for weeding. They produce coffee and bananas, in addition to a range of annual cash and food crops. The rich households in Singe typically cultivate up to 8 hectare (20 acres). Interestingly, FHHs are over represented among the wealthier households in Singe and among the poor in Tsamasi. Singe is close to Babati town where there is a market for farm produce. In addition to selling their produce, FHHs earn extra income by working in businesses such as hotels, shops, bars and schools.

Groups include Tsamasi Women income generating group (focusing on vegetable production and a tree nursery) and the oxen group (with 10 members, each owing either oxen or an implement; one owns a Magoye ripper and planter attachment). The Tsamasi oxen group was trained by LAMP and they were given a ripper to be used by group members without charges. If non members use the ripper they pay Tsh 15,000 per hectare.

<table>
<tr><td>No-tillage planter for animal draught power
</td><td>Farmers discussing no-tillage planter
</td></tr>
<tr><td>Farmers demonstrating hand jab planter
</td><td>Farmers trying out the hand jab planter
</td></tr>
<tr><td>Farmer in a RTCC field with beans
</td><td>Exploring a RTCC field during a field day
</td></tr>
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5. IMPACT OF RTCC ON LABOUR INPUTS AND ECONOMIC RETURNS

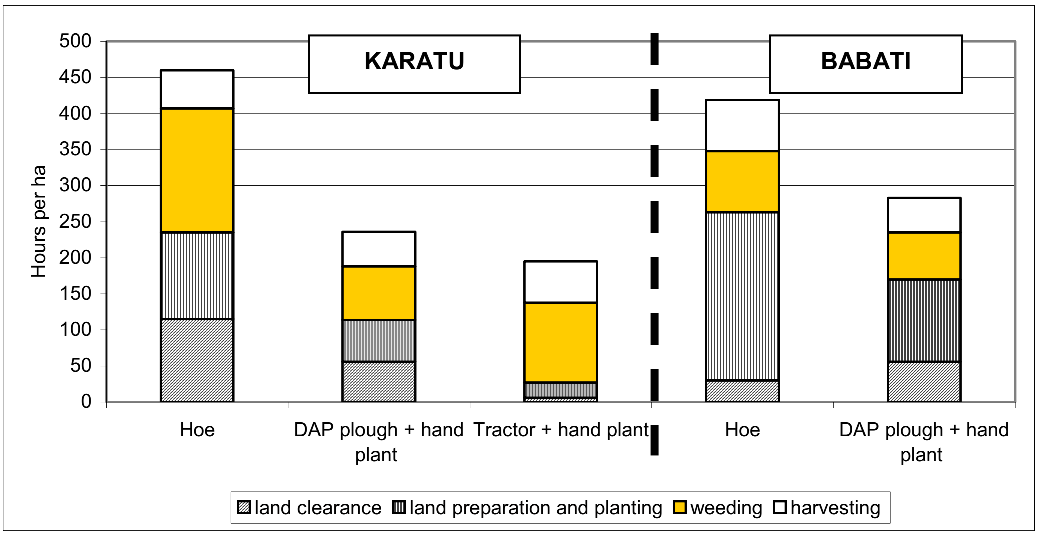
This chapter identifies the extent to which RTCC saves labour by comparing the impact of RTCC on labour inputs in comparison to conventional tillage methods in the two districts. It also looks the implications of RTCC for gross margins, labour and farm power costs, and returns to labour. Supporting data are presented in Appendices VII (trial data by cultivation system), VIII (gender division of labour), IX (gross margins by cultivation system) and X (labour and farm power work rates and costs).

As has been noted elsewhere in this report, the results should be taken as indicative of potential trends, since they are based on a small sample and one season.

5.1 Overview of Labour Inputs in Conventional Cultivation Systems

The labour intensive nature of the conventional cultivation system is demonstrated in Diagram 5.1. Hoe cultivators spend between 400 – 460 hours cultivating one hectare of beans during the short rains season. The amount of time saved using DAP or tractors for land preparation are considerable: 50% and 60% savings, respectively, over the hoe system in Karatu. A similar picture holds true for Babati: DAP cultivation reduces the labour input by 30% and tractors by 55%.

Diagram 5.1: Labour Inputs in Conventional Cultivation Systems, Karatu and Babati Districts



Source: Study data for short rains, 2002 with exception of tractor data in Babati, long rains 2003; full details in Appendix VII, Tables 1 and 2
Karatu sample: hoe cultivators (three plots); DAP (five plots); tractor (two plots)
Babati sample: hoe cultivator (one plot); DAP (two plots)

There are differences between the two districts in terms of the most time consuming task. For all farm power groups in Karatu, weeding was the most labour intensive task in the short rains whereas, in Babati, hoe and DAP farmers spent proportionally more time preparing the land and planting since the two operations were performed separately.

(i) Conventional practices in Karatu

All operations are more time consuming for hoe cultivators, with the exception of harvesting since the yields tend to be smaller than other cultivation systems. In Karatu, land is usually cleared by slashing weeds and removing crop residues prior to planting. This task is more onerous in hoe systems because weed infestation tends to be higher in fields which have been tilled by hand than by DAP. There are considerable savings in time if the residues are burnt in the field rather than removed physically but this practice is illegal. Grazing by livestock is also a time-efficient way of clearing the land.

In the short rains in Karatu, land preparation and planting tend to be performed simultaneously. Some hoe cultivators already practice a form of reduced tillage due to poverty, by digging and planting at the same time, a task which usually requires at least two people[22]. DAP farmers usually plough and plant together by dropping the seeds into the furrow created by the plough and covering them with the next pass[23]. This requires at least three people (two working with the oxen and one dropping the seeds) and two pairs of oxen. Households hiring tractors broadcast the beans by hand and incorporate them with a disc plough.

The task of weeding is particularly onerous under hoe cultivation, requiring over 40 days weeding per hectare and representing almost 40% of total labour inputs (Box 5.1). Depending on the level of weed infestation, two or three rounds of weeding are required plus one round of uprooting weeds. In this study, one of the farmers who had prepared his land by tractor had an unusually high level of weed infestation; hence the large amount of time spent weeding (28 days per ha, accounting for 55% of the total labour inputs).

Box 5.1: The Struggle of Weeding

Hand hoe farmers struggle to weed their entire area. When they complete one weeding, the other end of the farm is already infested again. Some weeding is done late due to family labour shortages, such as attending to the sick or having to wait until school closes so the children may assist. Late and incomplete weeding can account for more than 40% of yield losses for small scale farmers in Karatu and Babati Districts.

Source: Mariki, pers. corresp.

(ii) Conventional practices in Babati

The most time consuming tasks for hoe and DAP farmers in Babati are land preparation and planting (accounting for 55% of the total time of hoe cultivators and 40% for DAP cultivators) (Diagram 5.1). Hoe farmers first dig the whole plot and, one month later, dig basins for the planting seeds – a task which requires two people. Likewise, DAP farmers plough the field once to break the soil surface after livestock grazing before the rains and, one month later, plough a second time, dropping the seeds in the furrow behind the plough.

5.2 Impact of RTCC on Labour Inputs

(i) Labour requirements

RTCC enables particular tasks to be completed in a shorter time than the conventional method by reducing the size of the task (for example, cover crops suppressing weeds or no-till planting) or performing two operations simultaneously (for example, opening up the land and planting). Moreover, conservation equipment also requires fewer people to operate (Table 5.1) and fewer draught animals. The jab planter requires only one person to make the holes and plant seeds, whereas any other method requires at least two people. Planting by hand hoe requires one person to dig the hole and another to place and cover the seed.

Table 5.1: Labour Requirements for Planting with Different Equipment

Implement	Number of people required
Hand hoe	1 digging; 1 planting
Hand jab planter	1 planting
DAP plough/ripper and drop seed in furrow	2 working with oxen, 1 planting
DAP no-till planter/ripper planter	2 working with oxen

Any DAP system requires a minimum to two people: one to lead the animals and the second to operate the equipment. In conventional DAP tillage and ripper systems, additional labourers are required either to plant seeds in the furrow or to broadcast. DAP planters and ripper planters dispense with the need for the third person. The knife roller, ripper and no-till planter require only two animals instead of the usual four because the equipment is lighter than the conventional plough and does not require heavy draught power to invert the soil.

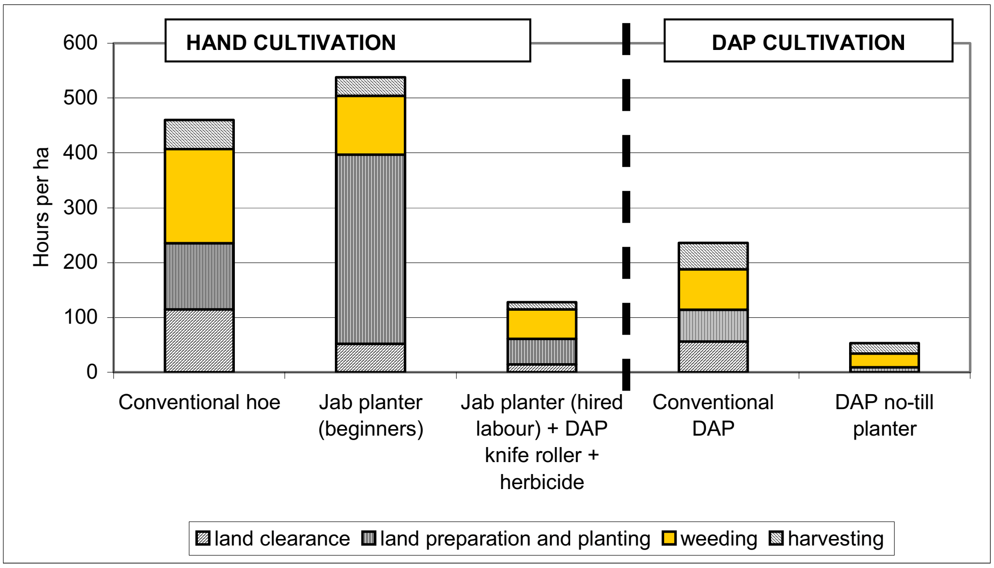
[22] Although this saves time planting, couch grass becomes a real problem on the surrounding untilled land.
[23] Occasionally DAP farmers plough first and plant at a later date.

(ii) RTCC in Karatu

An overview of the impacts of RTCC on labour inputs is illustrated in Diagram 5.2. During the trials, labour inputs were reduced by 75% in the hoe system for farmers using the jab planter together with the DAP knife roller, and by 80% in the DAP system when a no-till planter was used. The labour inputs for the DAP no-till farmer were exceptionally low because his land had been cleaned by grazing livestock, and he experienced very low weed infestation. These savings are discussed in more detail below.

When farmers are unfamiliar with the new technology, it may take some time to reap labour saving benefits. This is demonstrated by the group of three widows who used the jab planter for the first time. Although they saved time on land clearance and weeding, they spent substantially more time planting with the jab planter than the conventional hoe cultivators, and their total labour input increased by 15%. In contrast, the two men who worked as hired labourers were also very interested in using the jab planter and quickly mastered it.

Diagram 5.2: Labour Inputs for Conventional and RTCC Systems, Karatu District



Source: Study data, short rains 2002, full details in Appendix VII, Table 1
Sample: conventional hoe cultivators (three plots), jab planter beginners (three plots), jab planters with hired labour (two plots), conventional DAP cultivators (five plots) and DAP no-till planter (one plot)

Hoe cultivators

Three modifications to the conventional hoe system were examined during the trials and the data indicate that significant savings in labour can be realised in all activities (Table 5.2). Labour inputs are reduced by over 50% if crop residues are left on the field and one application of herbicide[24] is used at planting time instead of removing the residues manually. Once competent in its use, the jab planter reduces land preparation and planting activities by 60%. The greatest benefits are reaped in weeding (70%). Farmers found it was necessary to weed only once (rather than two or three times) as a result of reduced soil disturbance during land preparation and planting using the jab planter, the retention of residues as soil cover, and an application of herbicide at planting time. Overall, the findings suggest it is possible to save over 250 hours on land preparation through to weeding activities, representing around 45 workdays per hectare per season.

[24] The labour data for herbicide only relate to the time spent spraying and do not include any time for fetching clean water (approximately 200 litres per hectare).

Table 5.2: RTCC Trials for Hand Cultivators, Karatu District

Activity	System (hours/ha)		Labour saved by RTCC over conventional	
	Conventional	RTCC	Hours saved/ha	%
Land clearance	slash and carry off the field (115 hours)	slash (only) and herbicide application at planting time (52 hours)	63	55
Land preparation and planting	digging and planting (120 hours)	jab planter (47 hours)	73	60
Weeding	hoe and panga, rouging (172 hours)	hoe and panga, rouging (54 hours)	118	70
Total savings (land clearance to weeding)			**256**	**60**

Percentages rounded to nearest 5%
Harvesting data excluded
Source: Study data, full details in Appendix VII, Table 1
Sample: conventional data (three plots), RTCC data (four plots)

DAP users

The use of the DAP no-till planter (which enables farmers to plant directly through covered soil) offers the greatest potential savings by reducing the labour input for land preparation and planting by 85% (Table 5.3). Moreover, it can be used in association with the DAP-drawn knife roller (to crush the previous season's crop residues which are then left in the field). The knife roller, together with one application of herbicide, saves 75% time on land clearance. As a result of reduced soil disturbance and herbicide, weeding activities can be reduced to rouging, reducing labour inputs by 65%. Overall savings of the full RTCC system for DAP cultivators are in the order of 75%.

Table 5.3: RTCC Trials for DAP System, Karatu District

Activity	System (hours/ha)		Labour saved by RTCC over conventional	
	Conventional	RTCC	Hours saved/ha	%
Land clearance	slash and carry (56 hours)	DAP knife roller and herbicide application at planting time (14 hours)	42	75
Land preparation and planting	mouldboard plough, planting by hand behind plough (58 hours)	DAP no-till planter (9 hours)	49	85
Weeding	hoe and panga (74 hours)	rouging (25 hours)	49	65
Total savings (land clearance to weeding)			**140**	**75**

Percentages rounded to nearest 5%
Source: Study data, full details in Appendix VII, Table 1
Sample: conventional data (five plots), RTCC data (three plots)

(iii) RTCC Babati

DAP ripper

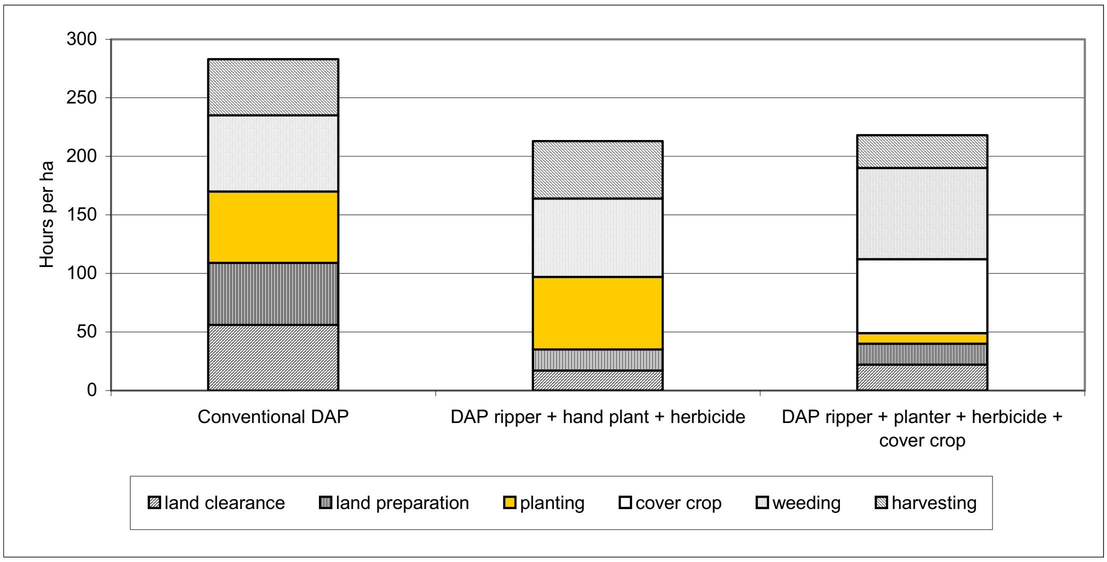
The use of the DAP ripper generates substantial savings in the time spent on initial land preparation (65%) (Table 5.4 and Diagram 5.3). Not only is the task completed more quickly, it also only requires two oxen instead of four which are used with the mouldboard plough. However, there are few savings, if any, during the second ripping when the seeds are planted in the ripper furrow by hand. This operation is as labour intensive as planting behind the plough. Significant benefits are reaped when the ripper planter attachment is used since it only requires two people instead of three for planting, and planting times are reduced by 85%. Weeding remains on a par with conventional DAP systems (in terms of hours per hectare) but represents a higher proportion of total labour inputs (around 33% rather than 25%). Overall, the full ripper system with planter reduces labour inputs by 50%.

Table 5.4: RTCC Trials for DAP Ripper System, Babati District

Activity	System (hours/ha)		Labour saved by RTCC over conventional	
	Conventional	RTCC	Hours saved/ha	%
Land clearance	slash and carry (56 hours)	slash and herbicide application (20 hours)	36	65
Land preparation	mouldboard plough (53 hours)	ripper (18 hours)	35	65
Planting	mouldboard plough, planting by hand behind plough (61 hours)	by hand in ripper furrow (62 hours)	- 1	-1
		ripper planter attachment (9 hours)	52	85
Weeding	hoe and panga (65 hours)	hoe (when use herbicide for land clearance) (67 hours)	-2	-5
Total savings (land clearance to weeding)			**121**	**50**

Percentages rounded to nearest 5%
Source: Study data, full details in Appendix VII, Table 2
Sample: conventional data (two plots), DAP ripper (two plots)

Diagram 5.3: Labour Inputs for DAP Conventional and RTCC Systems, Babati District



Source: Study data, full details in Appendix VII, Table 2 (first column short rains 2002; second two columns long rains 2003)
Sample: conventional DAP (two plots), ripper examples (one plot each)

Farmyard manure and cover crops

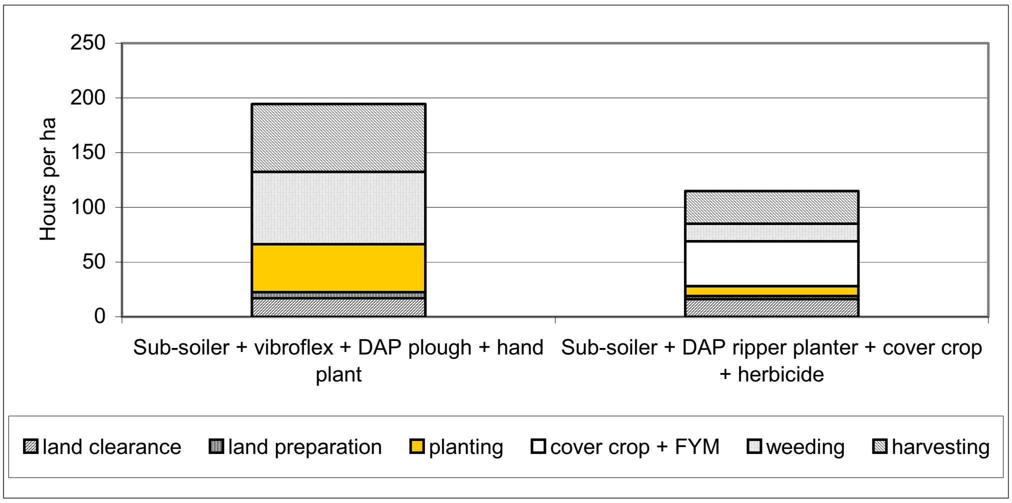
Two aspects of the RTCC system are labour demanding, rather than saving. The application of farmyard manure, which is a recommended practice with DAP ripping, requires transporting to the fields as well as labour for distributing it along the furrows (the latter is estimated to take 24 hours per hectare).

In the long rains, cover crops (such as mucuna and lablab) are planted by hand between the maize crops, 2 – 4 weeks after the main crops have emerged. This requires a substantial additional input of labour (of up to 60 hours per hectare, depending on the plant spacing and the state of weed infestation) but benefits are reaped in terms of fewer weeds and improved soil fertility in subsequent seasons (Table 5.4).

Tractor-based systems

Two farmers participating in the study used a mixture of tractor- and animal-drawn implements for land preparation and planting (Diagram 5.4). After sub-soiling, one used a tractor-drawn vibroflex for initial loosening of the soil, prior to planting by hand behind a DAP plough in the conventional manner. Weeding still accounted for one third of the total labour inputs in this system. The other farmer used the DAP ripper with planter attachment after sub-soiling, and reduced tillage labour inputs by 75%. His overall labour inputs were 40% less than the other farmer, even though he applied farmyard manure and inter-row planted a cover crop.

Diagram 5.4: Labour Inputs for Tractor-based Systems, Babati District



Source: Study data, full details in Appendix VII, Table 2 (long rains 2003); each example (one plot)

(iv) Implications for gender workloads

The gender division of labour is influenced by the source of farm power, activity, sex of household head and household wealth. From the field data (details in Appendix VIII) it was found that:

- all operations directly related to the use of DAP or tractors were performed by men in both conventional and reduced tillage systems;
- women sometimes planted behind the draught animals but only men planted behind tractors;
- herbicide applications were only made by men;
- in hoe and DAP households, the household head (female or male) tended to take the lead in many activities;
- in richer households most of the operations were performed by male hired labourers (female household members sometimes helped with in weeding and harvesting);
- there was a slight tendency for women to play a greater part in weeding but often the associations noted above were more dominant.

In many instances, who benefits from labour saving associated with RTCC is household-specific. For some activities, gender roles take precedence over household type. Thus, men benefit from time saved associated with using DAP or tractors more efficiently; women benefit from DAP-related technologies which reduce planting activities (such as the no-till planter or the ripper planter); and women also benefit from any reduction in the time spent weeding.

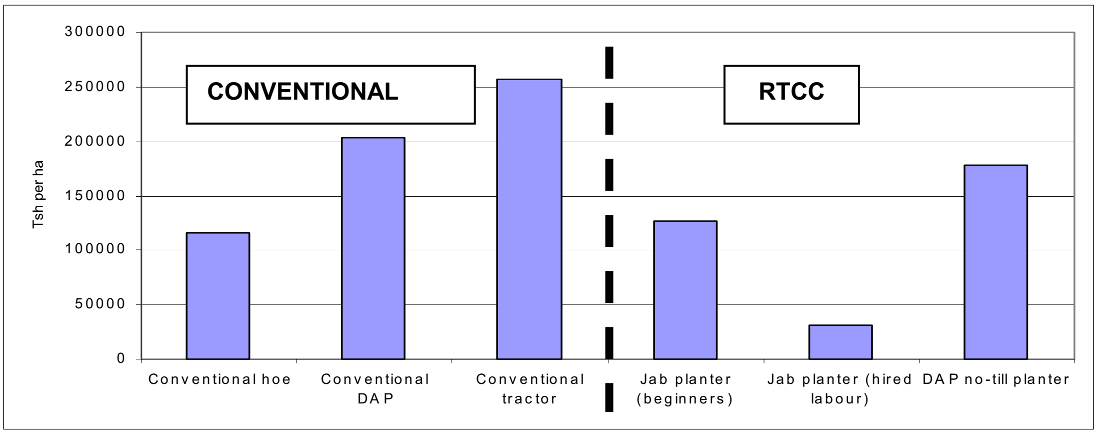
5.3 Economic Analysis

This section examines the impact of RTCC on gross margins and the returns to labour. The full data are at Appendix IX.

(i) Gross Margins

Under conventional cultivation systems in Karatu, gross margins per hectare of beans rose from around Tsh 115,000 per hectare for hoe cultivators to Tsh 200,000 for DAP users, to Tsh 250,000 for households using tractors during the short rains of 2002/03 (Diagram 5.5). Farmers practising RTCC achieved mixed results due to variability in their yields but were generally comparable to the conventional systems. The farmers who hired labour to operate the jab planter, planted early (towards the end of October), but were hit by an unexpected dry spell which lasted for three weeks and reduced their yields considerably. In contrast, the beginners using the jab planter planted later (in mid November) immediately after the regular rains and, partly as a result of favourable weather conditions, achieved a bumper harvest. This enabled them to absorb the inputed cost of the herbicide used during land clearance (which, in reality, was borne by the project) without reducing their gross margin.

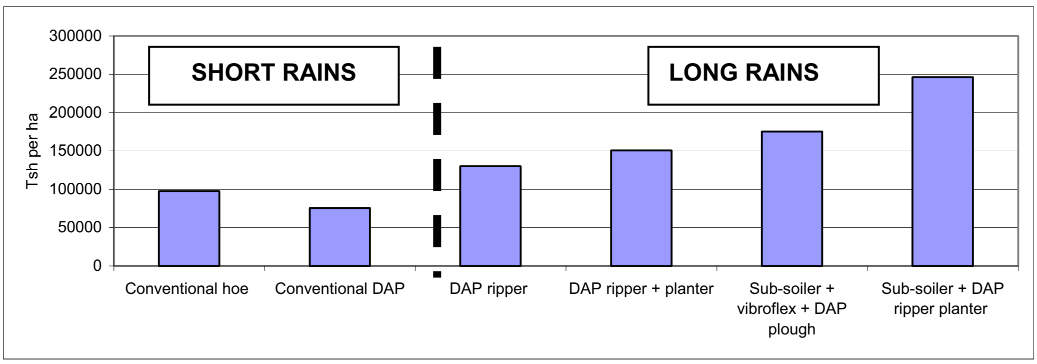
Diagram 5.5: Gross Margins under Different Cultivation Systems, Karatu District



Full details in Appendix IX, Tables 1 and 2, short rains 2002/03
GM = gross revenue less variable costs (seeds, herbicide, sacks)

In Babati, the beans planted during the short rains at Tsamasi suffered from a heavy infestation of pests. The hoe cultivator spent several days removing the pests by hand, whereas the conventional DAP farmers did not do so and suffered in terms of their final yield and gross margin (Diagram 5.6). The gross margins achieved by the farmers growing maize in the long rains using a tractor for sub-soiling and planting with DAP, were greater than those using the DAP ripper.

Diagram 5.6: Gross Margins under Different Cultivation Systems, Babati District



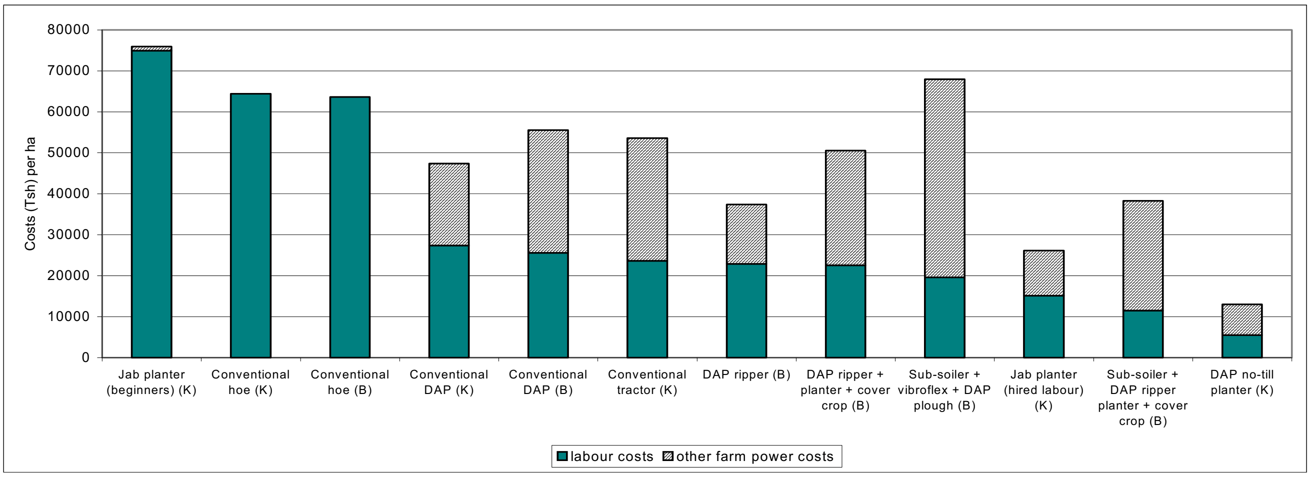
Full details in Appendix IX, Table 3, 4 and 5, short rains 2002/03 and long rains 2003
GM = gross revenue less variable costs (seeds, herbicide, sacks)

(ii) Farm power costs

For the purpose of analysis, the hourly labour inputs were converted to workday equivalents, according to the task (Table 1, Appendix X). The length of a typical working day was derived from the field data. Costs were assigned to the labour input, based on the daily wage rate for different activities (ranging from Tsh 500 per day for weeding and harvesting, to Tsh 1000 per day for land clearance and digging). The cost of planting depends whether it was being done by hoe or jab planter (Tsh 1000 per day) or dropping the seeds behind a plough or ripper (Tsh 500 per day). The cost of non-labour farm power inputs (such as DAP ploughing, ripping and planting; tractor sub-soiling, vibroflex and ploughing) were calculated using the standard hire charges per hectare (Table 2, Appendix X).

The total farm power costs were highest for the conventional hoe cultivators[25], the beginners using the jab planter and the farmer using a tractor for sub-soiling and vibroflexing and DAP ploughing (between Tsh 60,000 – 75,000 per ha) (Diagram 5.7). At the other extreme, experienced jab planter users and the farmer using the DAP no-till planter reduced their power costs to less than Tsh 30,000 per ha. The RTCC cultivation systems were effective in reducing the labour component of the farm power costs (as can be seen by the fall in labour costs in Diagram 5.7) by substituting non-labour farm power inputs (draught animals or tractors) for labour. However, the non-labour systems tended to be expensive, particularly in Babati when farmers follow the first DAP ripping or tractor sub-soiling by ploughing. It is only when RTCC requires minimal inputs of non-labour inputs that RTCC becomes cost-effective as well as labour saving. The change in the composition of farm power costs has particular implications for the affordability of RTCC for poorer households.

Diagram 5.7: Composition of Farm Power Costs by Cultivation System



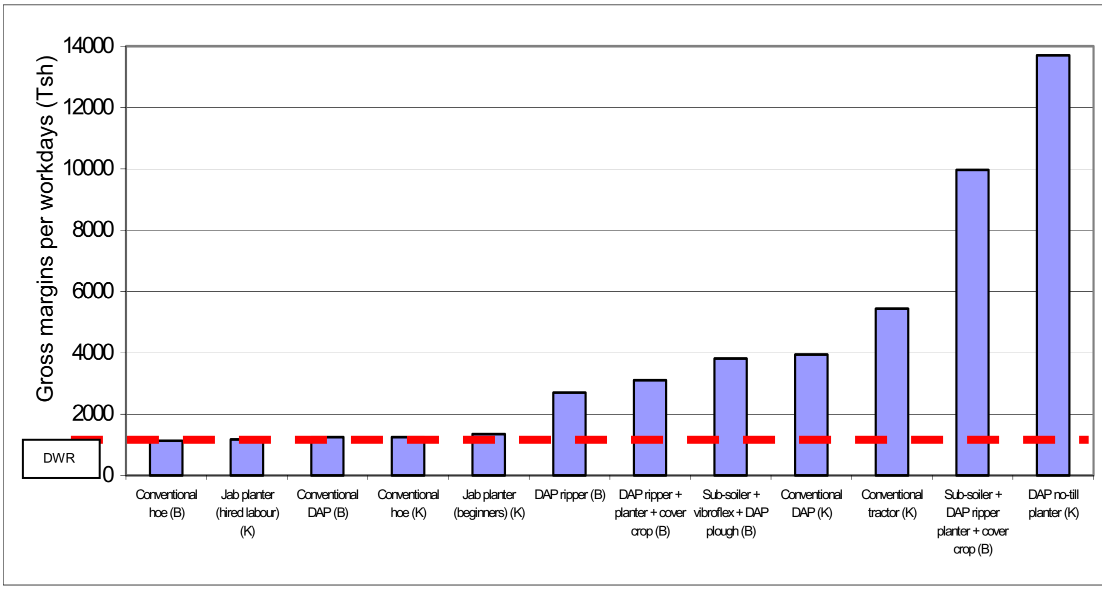
Note: For farmers using sub-soiler, only one third of cost included because benefits last for three years
B = Babati District, K = Karatu District

(iii) Returns to labour

An analysis of the returns to labour (gross margin per workday) indicate that the hoe and some conventional DAP cultivators generated returns which were slightly higher than the average daily wage rate of Tsh 1000 (Diagram 5.8). The returns to labour under RTCC in the hand system using the jab planter were on a par with the conventional systems. However, the returns to labour improved significantly with the use of DAP and RTCC. While the DAP ripper and ripper planter achieved 2.5 times the returns of the hoe cultivator in Babati, the conventional DAP realised three times the return of the hoe cultivators in Karatu. The no-till DAP increased the returns to labour tenfold.

[25] It is recognised that these labour costs are not actually paid when households use family labour but they represent the opportunity cost of their time (the earnings forgone by working on the household land rather than hiring themselves out to other farmers). Similarly, reciprocal labour is usually repaid at a later date. Occasionally hired labourers are paid in kind (food, beer and accommodation) rather than cash.

Diagram 5.8: Returns to Labour by Cultivation System



DWR = daily wage rate (Tsh 1 000)
B = Babati District, K = Karatu District

The returns to labour may also be examined in terms of yield produced. Although final yields were highly influenced by weather conditions and pest attacks (as noted in the discussion above), this variable provides an indication of the contribution of the cultivation system to household food self sufficiency. The results for the bean harvest grown during the short rains fell into three groups:

- less than 10 kg per workday: this was achieved by the conventional hoe systems at both study sites, the conventional DAP in Babati and the jab planter (beginners) in Karatu;
- 10 – 20 kg per workday: realised by the conventional DAP and jab planters using hired labour in Babati; and
- over 20 kg per workday: generated by the conventional tractor and DAP no-till planter cultivator in Karatu.

5.4 Conclusion

Whilst acknowledging the reservations about the quality of the data and the small size of the sample noted in chapter 4, it is felt that the findings are sufficiently compelling to conclude that it is possible to make significant savings in labour inputs with RTCC technologies and practices. They can also be effective in reducing total farm power costs and generating favourable returns to labour, either financially or in terms of produce harvested. The following chapter explores farmers' reactions to RTCC and chapter 7 examines the extent to which these RTCC technologies and practices are suitable for vulnerable households.

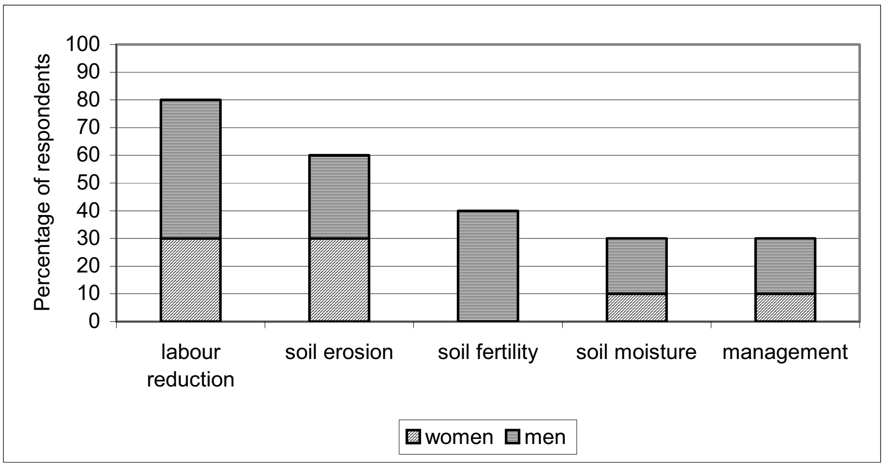
6. FARMERS' EVALUATION OF RTCC

This chapter reports on farmers' evaluation of RTCC, drawing on the experiences of those participating in the study, as well the reactions of the wider community.

6.1 Benefits of RTCC

The main benefit perceived by farmers participating in the RTCC trials was the reduction in weeds and, consequently, in the amount of time spent weeding (Diagram 6.1). This benefit was universal, cited by both women and men in both districts. Some benefits were site specific: reductions in soil erosion and improvements in soil fertility were noted in Karatu whilst in Babati, men using the DAP ripper noted increased moisture retention. Other benefits included increased yields, income and fodder from the cover crops, and better seed coverage using the DAP ripper. Due to the small sample size, it was not possible to detect any wealth-based differences in farmers' perceptions of benefits.

Diagram 6.1: Farmers' Perceptions of Main Benefits Associated with RTCC



Source: Farmers participating in RTCC trials (four women, six men, one missing observation)

(i) Weeding

In general, RTCC resulted in one less weeding operation by hoe in Babati and two light rougings in Karatu, rather than the two or three weedings which is undertaken in the conventional hoe system. Farmers also found that it was easier to remove the weeds in the RTCC plots.

In Kilima Tembo, the species of weeds had changed after two cropping seasons with RTCC. In conventional plots, the main weeds were *Cynodon dactilon* (Star Grass) and *Digitaria sp* (Quack Grass). These were suppressed in the RTCC plots but new weeds such as *Bidens pilosa* and *Gallinsoga* (Mack Donalds) were emerging. However, farmers found them easier to control than the former species[26]. In Babati, *Cyperus* (Nut Grass), *Cynodon* (Star Grass) and *Digitaria* (Quack Grass) were the dominant species in the conventional plots whereas in plots which had been ripped (and had applications of farmyard manure) *Richardia* (Congo Signal) and *Commelina* (Wandering Jew) were dominant.

However, since farmers participating in the study were applying different elements of RTCC (reduced or no tillage, ripping, cover crops and herbicides), it is not possible to be clear which element contributed to the reduction in weeds and change in species.

(ii) Soil moisture and fertility

Farmers observed differences in the green colour of crops planted in RTCC fields, the black colour of the soil in areas under cover crops, and moisture conservation. They reported that when the cover crops were slashed and left to decompose, they added fertility to the soil and

[26] Research in Karatu found that no tillage and cover crops reduced Mexican poppy weeds, and that mucuna and lablab gave the lowest count of weed species on no-till plots compared to conventional tillage (Mariki, 2003).

saved money buying inorganic fertilizer. It was noted that some cover crops, such as pumpkins, 'soften' the soil and increase the number of earthworms[27].

6.2 Evaluation of Conservation Tillage Equipment

A range of conservation tillage equipment was used during the study, from hand tools used for planting through to DAP implements used in reduced tillage systems. Whilst farmers were already familiar with the DAP ripper in Babati District, this was the first season in which the DAP knife roller and the DAP no-till planter were used in Karatu District. The evaluations are summarised in Table 6.1 and discussed in more detail below.

Table 6.1: Farmers' Evaluation of Conservation Tillage Equipment

Equipment	Advantages	Factors inhibiting adoption
DAP knife roller	• overcomes need to remove crop residues prior to planting	• not suitable for all types of weeds, grasses and emerging weeds
DAP no-till planter	• no need to remove cover crops • able to penetrate trash/cover crops (better than jab planter) because it has a coulter • do more than one operation at same time (plant and fertilize) • saves time over DAP planting (once become skilled in its operation) • requires fewer oxen and one less person than planting behind a plough	• expensive • not suitable for use in muddy soils • seeds need to be of uniform size • present design cannot be used for wheat
DAP Magoye ripper	• penetrates soil deeper than mouldboard plough • improves water harvesting • requires fewer oxen (two instead of four usually required for ploughing) because implement lighter and does not invert soil • faster than DAP ploughing • more uniform seedling emergence when seeds planted behind ripper than plough • can prepare land before rains • option of planter attachment, and wing attachment for ridging and weeding	• not possible to use with cover crops unless clean residues from furrow prior to ripping • ripping is often preceded by ploughing to control weeds
Jab planter	• no need to remove cover crops • able to penetrate trash/cover crops • one person makes hole and plants in one operation • do not have to bend over to operate • saves time over hand planting (once become skilled in its operation) • can use for inter-cropping between established maize crop	• at least 50% more expensive than traditional hoe • not suitable for use on moist soils with high clay content • requires learning period to use properly

Source: Field data

(i) DAP knife roller

Problems were experienced in using the knife roller to crush cover crops and crop residues prior to planting the next crop because the roller was too light to kill the cover crops and had to be filled with water to gain more weight.

(ii) Planting equipment

The criteria farmers used to evaluate the different technologies for planting emphasised the importance of saving labour, in terms of the ability to perform two or more operations at the same time (thereby requiring fewer workers) and completing the task in a shorter time period. Other characteristics included affordability, ease of use, and ability to work under no tillage conditions (that is, to be able to plant through a cover crop).

[27] These observations have been verified by separate studies conducted in Karatu (Mariki, 2003).

The results from discussions with farmers in Rhotia Kati are presented in Table 6.2. The hand jab planter was rated most highly, particularly by women, in terms of its labour saving attributes and ease of use (for example, it does not require the operator to bend over while working). It was, however, relatively expensive in comparison to the conventional hoe and did not work well in wet soils with a high clay content. The animal-drawn no-till planter was also rated highly on its labour saving characteristics and its ability to penetrate trash (because the coulter cuts through the residues); however, it is expensive and this puts it beyond the reach of many smallholders. The main benefits of the hoes were their affordability, ease of use, and ability to work with local soil conditions. However, their use is labour-intensive, and not well-suited to penetrating trash or soil cover, which is an essential feature of RTCC systems. This was particularly true for the onion hoe which is light and has a short handle (it was designed for weeding onions and is usually used on irrigated lands).

Table 6.2: Farmers' Evaluation of Equipment used for Planting under No-Tillage with Cover Crops

Criteria	Hand tools			DAP implement
	Traditional hoe	**Onion hoe**	**Jab planter**	**No-till planter**
Affordability	5	5	3	1
Ease of use	5	5	5	4
Ability to work in muddy soils	5	5	3	3
Ability to penetrate trash/cover	3	2	4	5
More than one operation at a time	1	1	5	5
Save time	2	1	5	5
Total	**21**	**19**	**25**	**23**

Maximum of 5 points allocated for each characteristic; the higher the points, the better the characteristic
Source: Women and men farmers in Rhotia Kati

(iii) Magoye ripper

In Babati District, farmers have had more than three seasons' experience of using the Magoye ripper. Farmers noted its benefits over conventional ploughing in terms of land preparation and planting. It penetrates the soil more deeply than the mouldboard plough (thereby improving water harvesting) yet requires fewer oxen (two instead of four animals) because the implement is lighter and does not invert the soil. The seed cover is more uniform when seeds planted in the ripper furrow. However, at best, the ripper alone belongs to a reduced tillage, rather than minimum tillage, system. If farmers do not use herbicide, they usually plough before ripping as a weed control measure, thereby resulting in a lot of soil disturbance. The option of integrating cover crops is constrained by the unsuitability of the ripper at present to work in crop residues[28]. The ripper also has wing attachments (for inter-row weeding and ridging) but this feature was not evaluated in this study.

6.3 Evaluation of Cover crops

The use of cover crops is relatively well established at the Karatu field sites through SARI initiatives but they have only been introduced recently to Babati. The evaluation with farmers not only included the main cover crops of mucuna and lablab, but also included several crops which are traditionally inter-cropped with maize during the long rains and have several of the characteristics of cover crops.

The range of criteria identified by farmers to evaluate cover crops indicate the multiple attributes they should have:

- increasing household resources either in the form of food or income;
- protecting and enhancing the quality of the soil through improving fertility and controlling erosion;
- suppressing weeds and reducing labour input;
- resilience to pests, diseases, drought;
- ease of management (including treatment prior to the following season);
- accessibility to cover crop seeds, both in terms of availability and price; and
- source of animal fodder.

[28] Adaptation of a coulter and a beam with a higher vertical clearance could avoid clogging on residues.

Women placed priority on choosing cover crops as a source of food and their ability to reduce time weeding (Table 6.3). The market attributes of cover crops were rated more highly by men than women.

Table 6.3: Criteria for Choosing Cover Crops by Sex of Farmer

Rank	Women	Men
1	Source of food	Source of food
2	Reduce time weeding	Market
3	Moisture conservation	Soil cover
4	Soil fertility	Soil fertility
5	Erosion control	Moisture conservation
6	Market	Reduce time weeding
7	Soil cover	Erosion control
8	Cover crop management	Cover crop management
9	Pest resistance	Drought resistance
10	Seed availability	Pest resistance
11	Drought resistance	Seed availability

1 = highest rank
Source: Field data from three sites (Kilima Tembo, Singe, Tsamasi)

When individual cover crops were ranked by farmers in Kilima Tembo[29] against these criteria, lablab and mucuna were the most popular, closely followed by crops which are traditionally inter-cropped with maize and have some cover crop characteristics (such as pumpkins, sweet potatoes and pigeon peas) (Table 6.4). If account is taken of farmers' priorities amongst the criteria, lablab was the preferred cover crop offering economic, weeding and soil quality benefits. Mucuna was rated as having weak economic benefits (food and market opportunities). These cover crops were considered to provide the best soil cover which contributes suppressing weeds and thereby reduces the labour requirement for weeding. Sunflowers and pigeon peas were also rated highly in protecting the soil since their presence in a field deters livestock grazers from letting their animals eat the maize crop residues. However, their erect habit combined with their low density (since they are inter-cropped with maize), mean they have little impact on controlling soil erosion and weed suppression. Crops which are traditionally inter-cropped with maize (such as pumpkins and sweet potatoes) were perceived to have a high economic value and their seeds are readily available. Pumpkins were ranked most highly at both sites in Babati District (particularly for its food, soil cover and weed control characteristics) followed by lablab (see Appendix XI).

The findings suggest that farmers' experience with inter-cropping and crops which have weed suppressing qualities, such as pumpkins, can act as entry points to introducing the concept of cover crops as an element of RTCC.

Table 6.4: Farmers' Evaluation of Cover Crops by Various Criteria, Kilima Tembo

Criteria	Cover crops		Crops traditionally inter-cropped				
	lablab	mucuna	pumpkins	sweet potato	pigeon pea	sunflower	safflower
food	3	1	5	5	4	4	3
market	5	2	3	4	5	5	5
reduced time for weeding	5	5	4	3	2	2	3
price of seed	3	3	5	5	5	3	3
soil fertility	4	5	3	2	4	3	2
soil erosion control	5	5	3	3	1	1	1
soil cover	5	5	4	3	4	4	2
ease of management	3	5	4	4	2	2	2
pest resistance	3	5	4	3	4	2	4
drought resistance	5	5	2	5	5	4	4
seed availability	3	3	5	5	5	2	2
Total	**44**	**44**	**42**	**42**	**41**	**32**	**31**

Maximum of 5 points allocated for each characteristic; the higher the points, the better the characteristic
Source: Women and men from Kilima Tembo

[29] The ranking is based on farmers' responses to cover crops grown in Kilima Tembo, Karatu District during long rains 2002 because cover crops are not usually grown during the short rains.

The specific characteristics of the four main groups of cover crops and inter-crops are described in Table 6.5. Although the value as a source of fodder was not mentioned during the ranking criterion, individual farmers rated lablab and mucuna highly due to this quality. However, mucuna is at risk from free grazing of livestock because it is not recognised as a crop whereas lablab is recognised as a crop due to the market value of the seeds.

Table 6.5: Farmers' Evaluation of Cover Crops

Crop	Advantages	Factors limiting widespread adoption
Lablab	• effective soil coverage and weed control (in particular *Digitaria*) through fast development and high biomass production • ease of management (decays quickly) • tolerant of drought • fodder for livestock • good market (eaten by Massai - middlemen buy from District and export to Kenya)	• farmers in study area not use as source of food • requires slashing prior to next season • susceptible to pest attack and requires spraying with insecticide
Mucuna	• effective soil coverage and weed control through fast development and high biomass production • ease of management • tolerant of drought • fodder for livestock • some farmers grind mucuna seeds and mix with corn bran to feed oxen	• use for human consumption not recommended (under research) although some farmers use it as a stimulant beverage • seeds not widely available and relatively expensive • weak market • strong plant so difficult to crush with knife roller • not recognised as a crop so more likely to be free grazed by livestock from other farmers
Pumpkins/ sweet potatoes	• traditional food crops inter-cropped with maize • cover soil and suppress weeds • seeds readily available and affordable	• none noted
Sunflower/ pigeon peas	• cash and food crop • protect land from livestock grazing • pigeon pea market includes export to Asia • pigeon pea seeds readily available • pigeon pea stems used for firewood	• erect habit so poor weed suppression • little impact on soil erosion

Source: Field data

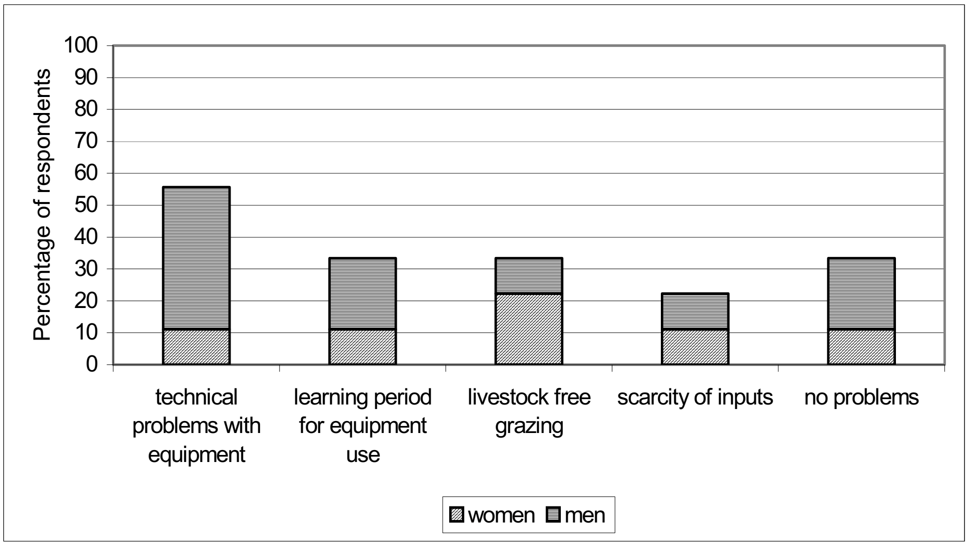
6.4 Evaluation of Herbicides

A small volume of herbicide (glyphosate) was given free to some farmers participating in the field trials. It was applied before planting, particularly in fields where it was proving difficult to crush the cover crops and crop residues with the DAP knife roller. Whilst farmers appreciated their labour saving attributes, they were considered to be expensive and, unlike cover crops, had no additional beneficial effects (such as improving the soil) other than weed control.

6.5 Overall Adoption Constraints

The main problems noted by farmers participating in the RTCC trials were related to technical aspects of equipment use (specifically the jab planter and the DAP ripper planter) and the need for a learning period to become familiar with the equipment (jab planter and DAP knife roller) (Diagram 6.2). Difficulties in finding cover crop seeds (lablab) and the absence of no-till equipment for growing wheat were also noted. The problem of free grazing by livestock on crop residues reflects the challenge of integrating RTCC into an established farming system where this practice is the norm. The three farmers who experienced no problems were already familiar with using the DAP ripper technology in Babati.

Diagram 6.2: Farmers' Experiences of Problems Associated with RTCC



Source: Farmers participating in RTCC trials (four women, five men, two missing observations)

6.6 Adoption, Adaptation and Rejection

An indication of the likely sustainability of the RTCC approach is the extent to which farmers participating in the initial trials continued to use or adapt the RTCC package in subsequent seasons. During the qualitative study it was found that all farmers continued to apply aspects of RTCC in the long rains of 2003, usually with modifications. This suggests that they understood the concept of RTCC (at least partially), appreciated its benefits and recognised the needs to adapt it to their own circumstances.

Farmers' responses in the second season are summarised below:

Adoption:
- 25% of the farmers left bean residues in the field after harvest to provide soil cover and mulch;
- 100% of RTCC farmers planted cover crops (75% lablab; 25% mucuna) and 75% of conventional farmers planted cover crops;
- 87% of the RTCC farmers used the jab planter during the long rains season;
- 25% of the RTCC farmers used the onion hoe;
- farmers continued to use the DAP ripper;
- one DAP owner in Karatu continued to use the DAP planter and another was keen to try it.

Adaptation:
- cover crops offered most flexibility to adapt to meet farmers' livelihoods needs: 37% of farmers used part of the cover crop as dry season fodder (mucuna and lablab); others introduced cover crops (such as pumpkins) which would contribute to household needs for food and cash, as well as suppress weeds; one switched variety of lablab to generate more biomass to suppress weeds;
- relay cropping with three crops (maize, beans and lablab) which enabled farmers to grow the cover crop without loosing their traditional intercrop of beans during the long rains. The beans were harvested one month before the maize and the lablab continued to grow to the next season;
- one farmer experimented with the onion hoe because the jab planter clogged on her muddy soils (adaptation in face of technical constraint);
- 50% of farmers using the DAP ripper either ploughed prior to ripping (as a means of weed control) or removed the cover crop from the ripping rows (adaptation in face of technical constraint);
- one farmer incorporated his cover crops prior to planting wheat because no-till planting equipment is not available for wheat (adaptation in face of technical constraint).

Rejection:

- only two farmers continued to use herbicide after the initial season. Herbicides were rejected largely due to their expense and other claims on household income, and partly due to an observed decrease in weed infestation (noted Karatu District).

6.7 Conclusion

This chapter has demonstrated that there are clearly some technical constraints which need to be addressed in order for RTCC to be a viable alternative to conventional tillage systems in Northern Tanzania. In particular, design features of equipment need to be adapted to local conditions (for example, the jab planter to work in clayey soils, the DAP ripper to work in crop residues without ploughing, and an effective means of crushing cover crops without relying on herbicides).

Despite these early teething problems, the responses from farmers participating in the study suggest they appreciated many benefits associated with the use of RTCC. The level of their interest is confirmed by the high level of adoption and adaptation of aspects of RTCC in the following season. The next chapter explores the extent to which RTCC is suited to the circumstances of the more vulnerable households within a community.

7. SUITABILITY OF RTCC FOR VULNERABLE HOUSEHOLDS

The quantitative data indicate there are technical and economic advantages of RTCC, and this is supported by the favourable feedback from farmers during the qualitative assessment. This chapter explores the extent to which RTCC is suitable for vulnerable households.

7.1 Characteristics of Vulnerable Households

This section describes some of the key characteristics of vulnerable households which may influence their ability to adopt or adapt RTCC.

(i) Socio-economic profiles

The 18 farmers participating in the study were grouped into five wealth categories based on their resource base and livelihood strategies (see Table 4.2).

The poorest households in the study consisted of two young widows in their 30s and one widow in her 50s. They cultivated around 0.75 hectare (1 – 2 acres) relying largely on family labour. They practised poverty-induced minimum tillage, planting in basins. They were food self-sufficient for about seven months each year and had received food aid in the past. Their livelihood strategies included selling grass for thatching materials, brewing sorghum beer to exchange for assistance with weeding or house repairs, casual labouring for payment in cash or food, looking after cows for neighbours in return for milk and manure, and renting out a proportion of land to raise some cash. One used to rent out half her plot to a tractor owner, and he ploughed the rest of her land in return. She stopped this arrangement after one season when he ploughed her fields very late which resulted in a low yield. The three FHHs only owned a few chicken. They were interested in RTCC, particularly to reduce weeding and improve yields.

Two poor households in the study were headed by men. Crop production was their main livelihood strategy and they regularly hired DAP for ploughing. They were keen to develop their farming skills: one was participating in the Soil Fertility Initiative (SFI) research trials on cover crops; the other had some land under irrigation and his wife traded in horticultural crops. They were self-sufficient in maize.

Not all households headed by women are poor, and the less poor group consisted of four such women. Their husbands died at least 10 years ago, and most were now in their mid 50s. They owned various livestock, including dairy cows, goats, sheep and chicken. They cultivated around 1.5 hectare (up to 4 acres) hiring DAP ploughing and casual labourers. Some grew wheat and hired a tractor for harrowing and a combine harvester. One owned two oxen, but no equipment and worked with her relative on a reciprocal basis (he had a pair of animals and a plough). Another has three young oxen and belonged to an on-farm training group to learn how to use the DAP ripper. Non-crop sources of income included milk, goats, and local brew. The youngest widow mentioned that she hired out her own labour in order to generate cash so that she can hire assistance at a future date when she is tired and short of time.

The middle income group was dominated by men heading households, aged from early 30s to mid 50s, with the largest household size of nine members. They all owned DAP and DAP equipment (mouldboard ploughs and, one farmer, two rippers and an ox-cart), as well as dairy cows. One also hired a tractor for harrowing and a combine harvester for wheat production. They cultivated at least 1.5 ha, generally using improved varieties and applying farmyard manure. This group was the most active in terms of membership and leadership of local organizations (such as farmers' marketing coop, oxen groups, community develop group, FARMAfrica, and village committees). Most were in regular contact with the village extension officer. The one FHH in this group was married but her husband did not have any responsibility for his family. She received Tsh 80,000 (US$ 80) from her local community development organization to establish a small retail shop and tea room; she also traded in crops. One of the MHH also had a small shop.

The richest farmers had diverse livelihoods, with significant sources of non-farm income (such as operating a retail shop or maize mill in an urban centre, employment as a civil servant, and truck driving). They cultivated over 2.5 hectare (6 acres) usually hiring in most of their farm power requirements (labourers, DAP and tractors). Only one owned draught animals but she also hired tractors for sub-soiling and vibroflexing. Farming enterprises included commercial activities such growing flower seeds under contract, wheat, coffee, and rearing broilers. These farmers purchased inputs (seeds, fertilizer), applied farmyard manure, and were in regular contact with the extension service.

(ii) Inventory of farm tools

One indication of the poverty experienced by the poorest households is their very limited equipment inventory (Table 7.1). The poorest usually had the bare minimum of farm tools, many were old, and they often borrowed from others. The total value of their tools at replacement cost was Tsh 7500 (US$ 7.50). The middle wealth households had the strongest equipment base, including oxen and a plough or ripper (but no-one in the study owned an ox-cart or DAP harrow); the total asset value was Tsh 110,000 (US$ 110) excluding the oxen. The richest households maintained a full inventory of hand tools (including shovels, slashers, rakes and wheelbarrows) but, as noted above, tended to hire in much of their farm power requirements.

Table 7.1: Equipment Inventory by Household Wealth

Equipment and use of hire services	Rich (FHH + MHH)	Middle wealth (FHH + MHH)	Less poor (FHH)	Poor (MHH)	Very poor (FHH)
Household size	8	9	6	5	7
Average number of tools per household					
Axe	1	1	-	1	1
Panga	2	1	1	1	1
Hoe	3 – 4	4	3 – 4	2	2
Sickle	1	1	1	-	1
Sprayer	1	1	Borrow	borrow	-
Draught animals (oxen)	generally 0	4	0 – 2	-	-
DAP plough/ ripper	-	1	-	-	-
Hire farm power services					
Hire labour	yes	yes	yes	-	very occasionally
Hire DAP	yes	-	yes	yes	-
Hire tractor	yes	occasionally	-	-	-
Approximate value of inventory at full replacement cost					
Tsh (US$)	61,000 ($61)	110,500 ($110) excluding oxen	8000 ($8) excluding oxen	6500 ($6.50)	7500 ($7.50)

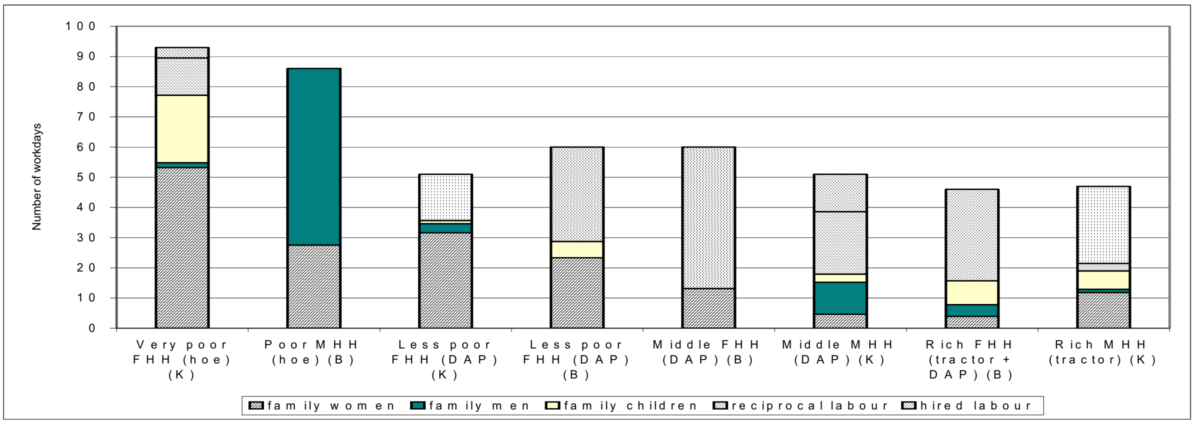
See Appendix XII for equipment prices
Source: Individual household interviews

(iii) Sources of farm power

The poorest households, relying on hoe cultivation, had the most labour-intensive farming system (Diagram 7.1). Most of their labour inputs were sourced from household members, with the household head contributing over 55% of the inputs. The contribution of children was also crucial in the poorest FHHs where they provided one quarter of the labour (representing over 20 workdays per hectare). Poor households headed by men were able to draw on their wives for substantial additional labour inputs. Reciprocal labour was also important for the poorest FHHs. For the non-poor households, hired labour was the dominant source of labour, typically providing at least half of the inputs.

Nevertheless, it is difficult to draw definite associations between the source of labour and household wealth. Household composition, the presence of relatives within the neighbourhood, and access to remittances influence labour sources. Hence one poor FHH used remittances to hire labour, whilst some farmers in the middle income groups made extensive use of reciprocal labour, and the richest farmer deployed his wife and children for weeding and harvesting. Proportionally more of the reciprocal labourers were women whereas hired labourers were more usually men.

Diagram 7.1: Sources of Labour by Wealth Group under Conventional Systems of Cultivation



B = Babati District, K = Karatu District

(iv) Barriers to adoption among vulnerable households

The findings from the earlier joint IFAD/FAO study of labour constraints conducted in western Kenya found that barriers to adopting labour saving technologies and practices, such as RTCC, tended to be more extreme amongst the most vulnerable households (Bishop-Sambrook, 2003). Households headed by widows, grandparents and orphans were becoming more common in the community, often as a result of HIV/AIDS. Their ability to adopt was constrained by a shortage of labour, limited cash, depleted assets, and gaps in their knowledge and skills base (Table 7.2). Under these circumstances, they were both unwilling and unable to expose their households to any risks that may threaten their very existence. It is in this context that the suitability of RTCC for vulnerable households is being evaluated.

Table 7.2: Constraints Facing Vulnerable Households, Western Kenya

Vulnerable households	Constraints to adopting technologies and practices
Female-headed households	• Time: care of husband during sickness, loss of husband on death • Cash: purchase of medicines and treatment during sickness, loss of income generated by husband, purchase of medicines for wife and children • Asset base: sale during sickness exacerbated by funeral and property grabbing by relatives • Awareness/skills: often determined by gender division of labour
Grandparent-headed households	• Time: additional time required to care for young orphans but older orphans may assist with work • Cash: additional demands to meet needs of orphans • Asset base: may have already distributed major assets to children • Awareness/skills: limited time and energy to attend meetings and gain new skills
Orphan-headed households	• Time: time and energy available but may have aversion to farming which is common amongst youth • Cash: extremely limited • Asset base: eroded during parents' illness and death • Awareness/skills: may not have had time to learn from parents • Age: if under 18 years old, not eligible to open bank account, own land, register an organisation

Source: Bishop-Sambrook (2003)

7.2 RTCC in the Context of Vulnerable Households

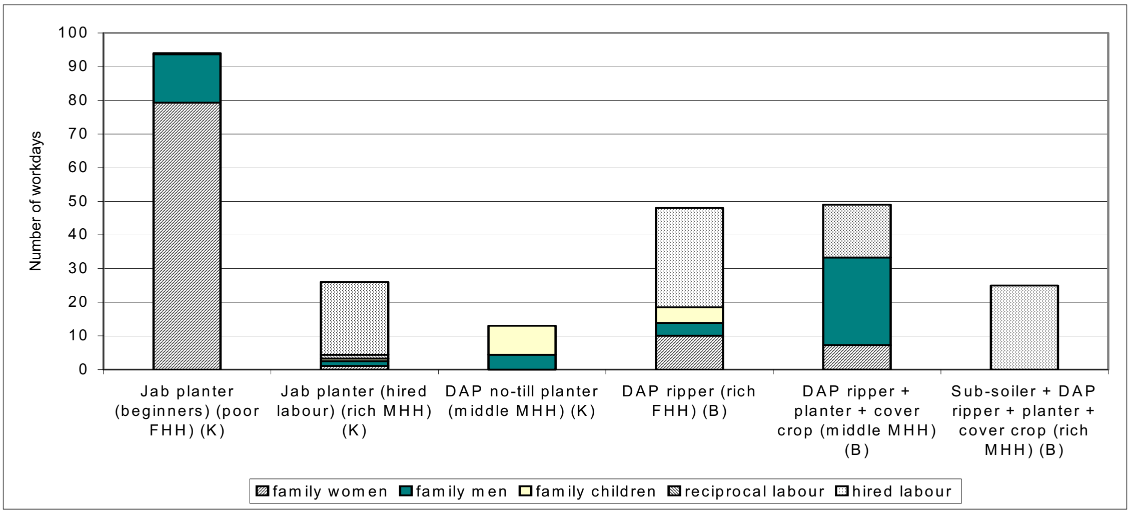
It was found during the quantitative analysis of RTCC (chapter 5) that most RTCC systems offer the potential of substantial labour savings but they may not be reaped in the first season. Moreover, they generate returns which are at least comparable to the conventional cultivation systems, in terms of gross margin per workday or yield per workday.

Hence the risks associated with adopting RTCC are threefold: the impact on workloads, affordability, and implications for the broader livelihood system.

(i) Impact on workloads

As has been demonstrated in a chapter 5, the introduction of a new RTCC technology or practice does not necessarily save labour in the first season. Additional inputs of time may be required to establish a cover crop, or learn how to use the technology effectively. The extent to which this has an implication for a household depends on its sources of labour. Very poor and poor households meet most of their labour inputs from household labour, supplemented by reciprocal labour. Hence they would bear the burden of adjusting to the new technology or practice. This is demonstrated by the labour profile of beginners using the jab planter (Diagram 7.2). In contrast, rich households make extensive use of hired labour.

Diagram 7.2: Sources of Labour by Wealth Group under RTCC Cultivation



B = Babati District, K = Karatu District

(ii) Affordability

There are two ways in which households may access conservation tillage equipment, by purchasing it or hiring the services of others who own the equipment.

Poorer households typically hold farm tool assets worth Tsh 7500 (US$ 7.50). This valuation, based on full replacement cost, overstates their value since many are old and worn out. During times of hardship, poor households postpone or defer their purchase of replacement equipment and borrow from others, if possible. Hence, they are likely to be extremely sensitive to any new technology or practice which requires an expenditure of cash. It is likely that the poorest households would struggle to purchase a jab planter (Tsh 10,000 – 15,000; US$ 10 – 15) which is ten times more expensive than the cheapest hoe. They are unlikely to be interested in the alternative of hiring labourers with a jab planter since they generally meet all their own labour requirements from within the household. These households face the same constraint with regards to growing cover crops if they need to be crushed prior to the following season. Whilst the DAP knife roller and herbicide represent a very time-efficient way of land preparation, they also require a cash outlay or payment in kind. Cash expenditure would represent a real risk to poor households since they endeavour to minimise these outlays: the average monthly expenditure for a poor household is in the order of Tsh 12,000 (US$ 12). Alternative arrangements, such as loaning out the land in lieu of payment or share-cropping, are not always very satisfactory.

While the less poor households can afford to purchase the jab planter, they usually prepare the land and plant crops by means other than the hoe. Hence the technology is not perceived to be relevant for their cultivation system. However, it may have a place amongst these households as a labour saving tool for inter-row planting.

Within the DAP system, the ripper (Tsh 60,000; US$ 60) is within the expenditure envelop of DAP owners as an add-on to an existing plough beam. However, other items, such as the knife roller (Tsh 300,000; US$ 300), no-till planter (Tsh 120,000; US$ 120) and the ripper planter (Tsh 75,000; US$ 75) are expensive and would represent a significant additional investment to the existing inventory of DAP owners (valued at Tsh 110,000; US$ 110 in total).

An alternative to purchasing equipment is to hire the services of others. Many of the middle wealth and richer households regularly hire labour and other sources of farm power. Hence it would be relatively easy, and even cost-efficient, for this group to switch from conventional cultivation systems to RTCC. For example, hiring the DAP no-till planter costs Tsh 7500 (US$ 7.50) per hectare, in comparison to the DAP plough which costs Tsh 15,000 (US$ 15) per hectare and requires an additional labourer to plant in the furrow behind the plough.

(iii) Implications for livelihood system

Several aspects of the conventional farming system pose challenges to the adoption of RTCC. First, there is a tradition of free grazing of crop residues by livestock after the harvest. One widow noted that her neighbour already let his livestock wander over her land when she grows maize. It is likely that this practice would increase if cover crops and crop residues are retained in the field.

Second, one of the livelihood strategies used by poorer households is to look after the livestock from richer households in return for milk and manure. Hence they require fodder and let their livestock graze on crop residues during the dry season. Whilst cover crops may compromise the practice of free grazing, they can be partly harvested for fodder and some farmers are already doing so.

Third, land rights are weak and potentially open to abuse (Box 7.1). The poorest farmers reported that it is difficult for them to claim their land rights because the process is cumbersome[30] and the outcome uncertain. The middle wealth group felt they could solve the problem among themselves, due to their higher socioeconomic status, without recourse to the village or district council.

Box 7.1: Cover Crops and Enforcement of Land Rights

A poor widow planted her field with lablab under no tillage. The field was then ploughed by a neighbouring farmer and planted with wheat. The farmer justified his actions because the field was covered with crop residues and he understood that it was not being cultivated. However, he should have asked for permission from the village council to establish whether the land was in use. The widow was aware of her land rights and complained to the village council. Fortunately, the council understood the problem because they had been informed about the study and had attended one of the field days. The council awarded the widow compensation.

Source: Study participant, Karatu District

In addition to considering the impact of RTCC on the livelihood system of poorer households as adopters, it is also relevant to consider their role as providers of casual labour. If RTCC is widely adopted in a community, it may significantly reduce the opportunities for poorer households to work as casual labourers.

[30] If the offender refuses to pay the fine and the farmers wishes to take the matter to the police, s/he has to stop working in their fields and have cash available for public transport to town, without being certain that the process will be successful. Hence most low income farmers do not seek justice if their crops are damaged.

7.3 Reaction of Vulnerable Households to RTCC

The poor FHHs who participated in the study were among the most enthusiastic participants. They tended not to belong to organizations because of membership fees and sometimes they felt that they were not eligible to join because the membership was self-selecting. They also had little contact with the extension services. However, they were keen to attend special events, such as field days, when they were notified.

This study, with a special focus on vulnerable households, presented an opportunity for researchers and extension staff to interact with these farmers on a regular basis. The farmers were keen to overcome their labour constraints: they were already practising reduced tillage through poverty (planting in hand-dug basins) and recognised that some of the crops they inter-cropped with maize had weed-suppressing qualities (pumpkins and sweet potatoes). Even though they struggled to master the jab planter, they welcomed the tool and perceived it to be a sign of progression from the hand hoe. They also valued cover crops which met their immediate needs of producing food and reducing time spent weeding. However, there was some concern about to how manage the cover crop prior to the next planting.

As a result of participating in the study, the self-confidence of these farmers increased, they gained greater respect in the community, and gained a voice as their views and opinions were being listened to.

7.4 Conclusion

The favourable response of the vulnerable households participating in the study suggest RTCC is an approach which can be adapted to suit their needs. To do so effectively, however, not only requires an appropriate mix of technologies and practices but also recognition by key stakeholders (such as researchers, manufacturers and extension agents) of the very real constraints facing such households. Ways in which vulnerable households may be included in RTCC initiatives are explored in the recommendations presented in chapter 8.

8. CONCLUSIONS AND FUTURE ACTIVITIES

The final chapter draws together the main conclusions emerging from the study and identifies future activities for scaling up conservation agriculture activities in the study districts.

8.1 Conclusions

(i) Labour shortages as a catalyst for conservation agriculture

Similar to the experiences of conservation agriculture in Brazil, land degradation has played a crucial role in the two study districts in sparking an interest in elements of conservation agriculture. However, unlike Brazil, land degradation and the threat it poses to rural livelihoods is not yet of a sufficient scale to result in widespread adoption of conservation agriculture. It may take the impact of HIV/AIDS and severe labour shortages to act as the catalyst for change, propelling African smallholders down the path of reduced tillage and cover crops, towards conservation agriculture.

(ii) Is RTCC the correct path to follow?

The study found that most RTCC systems offer the potential of substantial labour savings and generate returns which are at least comparable to the conventional cultivation systems, in terms of gross margin per workday or yield per workday. Greater benefits are reaped when more elements of RTCC are utilised together rather than in a piecemeal manner: such as the no-tillage of the land followed by direct planting with the jab planter or DAP no-till planter; or the DAP ripper with planter attachment.

Several features of the existing farming system have acted as entry points and facilitated the favourable response by the study participants to RTCC: the growing urgency to address labour constraints (particularly the burden of weeding); their familiarity with inter-cropping and growing crops with weed-suppressing qualities; and the high level of use of DAP (as owners or hirers). Among non-poor households, the hiring of DAP and tractor services provides an opportunity to introduce conservation tillage equipment.

Nevertheless, there are barriers to adoption. The benefits may not be reaped in the first season whilst users become familiar with the new technologies. Some RTCC practices require an additional input of labour, such as planting cover crops or applying farmyard manure in the DAP ripper systems. The equipment is expensive for the respective user group: the poorest would struggle to afford the jab planter whereas DAP and tractor users could afford it but it would only be appropriate for inter-row planting rather than as their main method of planting. No-tillage DAP implements, other than the ripper, are expensive. Cover crop seeds are not readily available and, at present, there is not an effective method (other than herbicides) for dealing with cover crops prior to the next planting season (particularly for the DAP ripper).

(iii) Is RTCC a path for vulnerable households?

The risks associated with adopting RTCC are threefold: the impact on workloads, affordability, and implications for the broader livelihood system. Very poor and poor households meet most of their labour inputs from household labour, supplemented by reciprocal labour; hence household members would bear the burden of adjusting to the new technology or practice. Their limited asset base and small income makes them extremely sensitive to any new technology or practice which requires an expenditure of cash. It is likely that they would struggle to purchase a jab planter which is ten times more expensive than the cheapest hoe. They also face financial constraints if they grow cover crops and need to hire DAP services for crushing with the knife roller or use herbicide. Poorer households also may find it more difficult to enforce their weak land rights and prevent free grazing on crop residues by other farmers.

Nevertheless, the poorer farmers who participated in the study were among the most enthusiastic participants. Even though they struggled to master the jab planter, they welcomed the tool and perceived it to be a sign of progression from the hand hoe. They also valued cover crops which met their immediate needs of producing food and reducing the time spent weeding. In addition, this study made these farmers more visible to researchers and extension staff and, as a consequence, they grew in self-confidence and gained greater respect in the community.

Widespread use of RTCC may have implications for two livelihood strategies adopted by poorer households. With the retention of crop residues in the field, it may be more difficult to find fodder for the livestock they look after on behalf of richer households. If RTCC is widely adopted in a community, it may significantly reduce the opportunities for casual labouring which is a common livelihood activity among poorer households.

8.2 Future Activities for Scaling-up Conservation Agriculture Activities in the Study Districts

Northern Tanzania is recognised as an area where much work has already been done to promote cover crops and DAP ripper technology (Karatu and Babati respectively). The initiatives in Babati District have benefited from an integrated multi-stakeholder approach to promoting DAP ripper technology and sub-soiling with the involvement of farmers, extension, manufacturers and retailers. LAMP is also addressing broader issue of land tenure and community planning of resources which are central to adoption of RTCC. In Karatu, there have been strong research-farmer-extension linkages.

The activities detailed below are of particular relevance to agencies working in the study area. However, they will also be of interest to organizations working in other communities where agricultural activities are being compromised by severe labour shortages. Two groups of activities have been identified in order to move conservation agriculture activities forward in the study districts:

(i) Extending the use of RTCC in Northern Tanzania

- ***appraise existing technologies under local conditions***: for example, CIMMYT has developed a DAP planter for use with wheat in Bolivia (which was subsequently modified in India to cope with greater residues in irrigated areas, Ekboir, 2001) and it could be tested by wheat-growing middle wealth and richer farmers in Karatu District;
- improve the ***suitability of equipment***: at present the DAP ripper is prone to clogging when working in crop residues – this problem may be overcome by introducing a disc coulter and increasing the vertical clearance of the beam; and develop a more effective means for crushing cover crops than the DAP knife roller without recourse to herbicides;
- validate a ***multipurpose conservation agriculture cropping system*** which provides fodder, food and income, as well as controlling weeds by keeping the soil covered throughout the year (growing beans and lablab or mucuna during the short rains; and various combinations of maize, pigeon pea, beans and lablab or mucuna during the long rains). Part of the cover crop would be harvested for fodder and part would remain in the field to provide mulch for the next crop);
- technical and economic evaluation of ***integrating livestock into RTCC systems***;
- reduce the ***pressure on removing biomass from fields*** for livestock fodder or firewood to enable farmers to leave pigeon pea roots on the crop land;
- other: assess the effect of different planting dates of inter-cropping lablab with maize on yields and weed composition; promote multipurpose cover crops; and promote the use of neen extract for pest control in lablab to replace insecticide.

(ii) Reaching out to vulnerable households

- encourage extension and research services to ***include vulnerable households within outreach activities*** and to be sensitive to their needs, perceptions and ability to take risk;
- develop ***low cost, low external input*** conservation agriculture systems: RTCC for the poorest should be based on very low use of external inputs, manual equipment, and cover crops with value as food, fodder and cash;
- ***minimise the risk facing adopters*** during their learning period as they become familiar with the new technology by enabling them to experiment in a safe environment (for example, through a group forum such as a farmers' field school for vulnerable households, and compensation for possible yield losses)[31];

[31] If RTCC is immediately profitable it may not be necessary to have financial incentives for middle wealth and richer farmers. However, the process of adoption could be facilitated if the financial risk is removed for innovating farmers.

- encourage the ***formation of user groups*** to jointly purchase conservation tillage equipment and share in its use;
- ***link with other initiatives*** which are enhancing the livelihoods of the rural poor and would provide an entry point for introducing labour saving technologies and practices based on RTCC.

If these actions are successful, additional activities will be required in order to go to scale. Such activities could include:

(iii) Further strengthening the enabling environment

- raise ***awareness*** about the role and potential benefits of reduced tillage and cover crops for vulnerable households amongst staff from the extension service, NGOs and research network, as well as the farming community. In particular, increase the ***understanding*** about the differing opportunities to promote RTCC depending on the household context, in particular their ability to purchase inputs and to take risks (for example, DAP and herbicides are not relevant for poorer households whereas the jab planter would not be of interest to richer households as their main planting implement) and gender roles (for example, saving time on DAP-based tillage is more likely to benefit men than women);
- ***adjust the conservation agriculture message and package*** to different farming systems and suited to household needs and resources;
- adopt a ***flexible approach*** to enable farmers to move from RTCC to conservation agriculture in a piecemeal manner (from Level 1 and 2 adoptions (Box 2.1) and subsequently to Level 3);
- promote the ***integration of conservation tillage and cover crops*** in the two study districts: activities in Karatu have tended to focus on cover crops whilst attention has exclusively focused on DAP rippers in Babati and both would benefit from a more holistic approach;
- strengthen ***local governance systems***: to increase security regarding land tenure (particularly important for households headed by women and orphans); protect user rights (important when the change in cropping system to the retention of crop residues on the land is not recognized as 'farming'); and resolve any livestock grazing conflicts;
- strengthen ***local institutions and their linkages in the RTCC innovation system***: manufacturers, research, farmers, retailers;
- encourage and support ***farmer-to-farmer technology dissemination***: through field days and exchange visits between farmers from Babati and Karatu, within each district and between the districts.

(iv) Improving access to RTCC inputs

- support the ***local manufacture*** of conservation tillage equipment through strengthening the linkages between local manufacturers, including small artisans who have the capacity to make some of the less complex equipment (such as the jab planter and DAP knife roller), researchers and farmers. One company (NANDRA Engineering) was approached during the study and duplicated the jab planter. However, in order to duplicate the no till planter, extra materials would be required such as crusted materials for the gears and hardened material. The disc coulter may have to be ordered from Brazil.
- facilitate the ***purchase of conservation tillage*** equipment: through the provision of financial services to user groups (for example, groups using the jab planter (farmers or labourers); DAP-owning groups to purchase a no-till planter, knife roller or ripper);
- support the ***formation reduced tillage-DAP hire services****:* provide technical support in operating a small business (offering farm power hire services) based on conservation tillage equipment (jab planters, DAP no-till equipment and no-till equipment for tractors through TFSC), repairs and maintenance of equipment, and ensure adequate training of operators and draught animals;
- establish farmers to undertake ***seed multiplication of cover crops*** for exchange and sale, such as lablab and mucuna, in areas where the seeds are in short supply;
- promote ***value adding activities for cover crops*** in order to maintain and enhance the value of cover crops (their current value may decrease if supply increases dramatically); for example, household oil processing of sunflower seeds or jam made from pumpkins.

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APPENDIX I: ORGANIZATIONS AND PEOPLE MET

Arusha

Dr Ally A Mbwana	Director, Selian Agricultural Research Institute (SARI)
Dr N F Massawe	Zonal Research Coordinator, Head of Livestock Programme, SARI
Dr Adolf Nyaki	Director, Mlingano Agricultural Research Institute
Mr Manfred Lieke	Managing Director, Tanzania Farmers' Service Centre (TFSC)
Mr Koshuma	Acting Director, Tanzania Engineering and Manufacturing Design Organization (Temdo)
Mr Wilson Baitan	Director of Agro-Technology, Centre for Agricultural Mechanization and Rural Technology (CAMARTEC)
Mrs Getrude Mdami	Acting Branch Manager TFA Arusha
Mr Rob Allport	Director VETAID, Tanzania
Mr Paul Laizer	SCAPA Coordinator, Arumeru
Mr Mwale	SCAPA Coordinator, Arusha
Mr Frederick J Mumbuli	Manager Finance and Advice In Development Assistance, Small Enterprise Promotion (FAIDA-SEP)

Karatu District, Arusha Region

Dr Bernadette Mwawado	District Agriculture And Livestock Development Officer
Mr D Kyiwera	Acting District Executive Director (DED)
Mr Amerson Njumbo	Mechanization Officer
Mr Macha	Manager TFA, Karatu Branch
Mr Siloh	Manager MBK
Mr Koro	Coordinator KDA
Mr Mollel	Land Use Planning Officer
Mr Marusu	District Crops Officer
Mr Edmund Howly	District Health Officer
Mr Ngowi	District Medical Officer
Mrs Husna Sandewa	District Maternal Mother and Child Health Coordinator
Mr Moruo	Karatu Medical Assistant
Sisti Haygaru	Village Executive Officer, Kilima Tembo

Babati District, Manyaru Region

Mr Raphael B Mbunda	District Executive Director
Ms L L Msoffe	District Extension Officer and LAMP Programme Coordinator
Mr Musa A Singisha	District Mechanization Officer
Mr Frank Lyimo	Land Use Officer
Mr Imeti	Division Extension Officer
Ms Ulla-Maj Jern	Development Adviser, LAMP Support Office
Mr Rogathe Mirisho	Programme Coordinator, Babati District Participatory Irrigation Development Programme (PIDP)
Mr Stanslaus Mkude	Programme Coordinator, PIDP Dodoma
Ms Zainabu Mnubi	Organization and Training Officer, Babati District PIDP
Mr Kasindei Massawe	Farmer Participatory Research Component Coordinator, Food and Agricultural Research Management (FARMAfrica)
Mr George Odhiambo	FARMAfrica Project Coordinator
Mr Damas Ngowi	Assistant FARMAfrica Coordinator

Kilimanjaro Region

Frank Alfred Lesiriam	Managing Director, Nandra Engineering Works Ltd

APPENDIX II: EVIDENCE OF LABOUR SAVING CHARACTERISTICS OF CONSERVATION AGRICULTURE

Table 1: Impact of Conservation Agriculture on Labour Inputs by Farming System

Country	Farming system	Conservation agriculture practice	Decrease in labour inputs over conventional system (%)	Reference
Latin America				
Brazil	Mechanized soya	No-till compared to conventional	10%	World Bank, 1998 cited by Pieri *et al*, 2002
Brazil	Mechanized maize	No-till compared to conventional	51%	World Bank, 1998 cited by Pieri *et al*, 2002
Brazil	DAP maize	No-till compared to conventional	55%	World Bank, 1998 cited by Pieri *et al*, 2002
Brazil	DAP bean	No-till compared to conventional	59%	World Bank, 1998 cited by Pieri *et al*, 2002
Brazil	Maize using DAP	No-till compared to conventional	68%	Melo cited in Landers, 2001
Brazil	Wheat and soya	No-till compared to conventional	31%	Denardin, 1998 cited by Pieri *et al*, 2002
Paraguay	Hand and/or DAP	No-till compared to conventional	12%	Sorrenson *et al*, 1998 cited by Pieri *et al*, 2002
Sub-Saharan Africa				
Ethiopia	*Teff* with DAP	From traditional *maresha* to ripping	80% in traction time (but 30% increase in weeding time)	Rockstrom *et al*, 2001
Ghana	Maize by hand	From slash and burn to no-till, no burn, mulching with herbicide	22% planting 51% weeding	Ekboir *et al*, 2001
Ghana	Maize by hand	From hoe cultivation to no-till plus herbicides	84% (see Table 2 below)	Soza *et al*, 1998
Nigeria	Manual	No-till compared to conventional	97% in field preparation **63% in planting time** 96% in weeding	Wijewardene *et al*, 1989 cited in Steiner, 1998
Tanzania	Maize with DAP	From mouldboard plough to shallow ripping	60% overall	Mkoga *et al*, 2001
Zambia	Maize with DAP	From mouldboard plough to shallow ripping	Reduction in planting time (but 120% increase in weeding time)	Muliokela *et al*, 2001
Zambia	Maize by hand	From hoe cultivation to basin planting	20% weeding	Muliokela *et al*, 2001
Zambia	Maize by hand	From hoe cultivation to basin planting	3% field preparation and planting (but additional 40% if only look at land preparation (see Diagram 1 below)) Additional 40% weeding	Haggblade and Tembo, 2003
Zambia	Maize by DAP	From mouldboard plough to shallow ripping	Additional 25% field preparation and planting Additional 30% weeding	Haggblade and Tembo, 2003

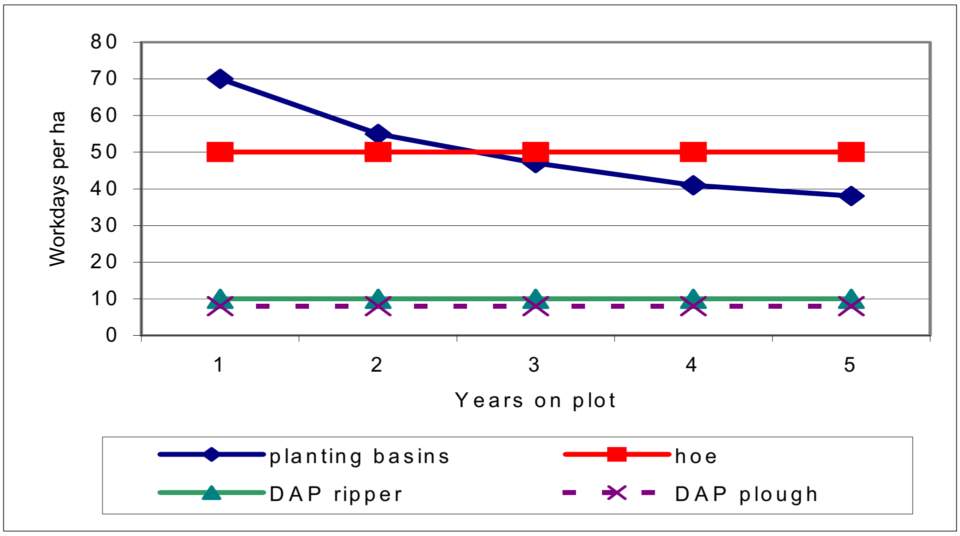
APPENDIX II: EVIDENCE OF LABOUR SAVING CHARACTERISTICS OF CONSERVATION AGRICULTURE (continued)

Table 2: Key Differences between Tillage Systems for 1 Hectare Maize, Ghana

Tillage system	Working days (from soil preparation to harvest)	Maximum area under good cultivation (ha)	Yields (t/ha)
Hand hoe	100 – 120	1 – 2	1 – 2
DAP + hand weeding	50 – 60	4 – 6	3 – 4
DAP + herbicides	25 – 30	8 – 12	4 – 5
No-tillage + herbicide	15 – 20	Up to 20	5 – 6

Source: Soza et al, 1998

Diagram 1: Labour Requirements for Field Preparation by Tillage System, Zambia



Source: Haggblade and Tembo, 2003

APPENDIX III: MEDICAL DATA FROM KARATU AND BABATI DISTRICTS

Table 1: Disease Treatment in Karatu District Hospital, 2001 and 2002

Disease	Ambulant treatment		In-patient treatment (on-station)		Deaths	
	2001	2002	2001	2002	2001	2002
Malaria	59276	41458	5376	3527	253	335
Pneumonia	12458	12387	1382	2160	6	6
Diarrhea diseases	10883	11349	587	655	-	12
Tuberculosis	-	144	-	145	11	8
Anemia		629		240	-	-
Acute Respiratory Infection	24974	20161	400	421	-	-
Intestinal worms	31626	5795	-	-	-	-
UTI (Urinal infection)				100		
STDs	4623	6998	-	-	-	-
Clinical AIDS *(with all signs of full blown AIDS)*	-	142	-	101	142	101

Source: District Medical Office, Karatu

Table 2: Disease Treatment in Babati District Hospital, 2000

Disease	Ambulant treatment 2000	In-patient treatment (on-station) 2000	Deaths 2000
Malaria	81008	6567	207
Tuberculosis	-	475	74
Anemia	1279	605	55
Pneumonia	16938	1769	52
Clinical AIDS *(with all signs of full blown AIDS)*		51	22
Diarrhea diseases	10376	575	14
Burns	-	50	4
Acute Respiratory Infection	31874	458	1
Complications of pregnancy		117	3
Fractures	16	84	3

Source: Health Management Information System, Babati District Hospital

Table 3: Blood Test Screening for HIV[a], Babati District, 2001 - 02

Age and sex		2001		2002		Average (2001-02)
		Number tested	% HIV +	Number tested	% HIV +	% HIV +
15 – 19 years	female	21	90%	20	70%	80%
	male	75	76%	24	58%	67%
20 – 24 years	female	117	62%	51	41%	51%
	male	319	81%	216	30%	55%
25 years and over	female	40	60%	85	47%	53%
	male	119	63%	486	42%	57%

[a] *The blood donors represent a random sample since they have been requested to donate blood for a relative, neighbour or friend who requires blood infusion.*
Source: Babati District Hospital

APPENDIX IV: CONSERVATION AGRICULTURE INNOVATION SYSTEM BY SECTOR

Organization	Activities	Methods to promote conservation farming	Linkages with other organizations
	Government		
District Agriculture and Livestock Extension Office (DALDO), Ministry of Agriculture	• provide extension services to promote use of fertilizer, improved seeds, improved breeds of dairy cows, improved milk processing, use of contours and trees, cover crops and leguminous species • under Conservation Tillage Project (CTP), promote technical package of obligatory construction of contours, DAP ripping, use of farmyard manure, specific row spacing, use of chemical fertilizer and weeding	• under CTP, provide soft loans to farmer group of 20 – 25 members covering improved maize seed, fertilizer, pesticide and 2 Magoye rippers per group. • 0.4 ha to be planted following technical package and loan to be repaid after harvest • technical assistance and follow-up provided by ward and village extension officers	SARI, TFSC
Selian Agricultural Research Institute (SARI), Arusha	• research, development and diffusion of sub-soiling and no tillage with cover crops • support from FAO, GTZ, IFAD, TFSC	• on-farm and on-station trials • demonstration plots • training • field days • provision of cover crop seeds • promotion of no-till equipment	TFSC, KDA, extension department
Centre for Agricultural Mechanization and Rural Technology (CAMARTEC), Arusha	• develops, adapts, disseminates appropriate technologies in agricultural mechanization (mainly ox implements), water supplies, sanitation, low cost housing, rural transport, alternative energy and post harvest • responsible for mandatory testing of all agricultural equipment and machinery • parastatal organization under Ministry of Industries and Commerce	• produced more than 150 jab planters	
Tanzania Engineering and Manufacturing Design Organization (TEMDO)	• applied engineering research and development institute • design and manufacture range of manual and engine-driven post harvest equipment • in process of being privatised but currently salaries received from Ministry of Industry and Commerce	• produced 10 Magoye rippers and subsoilers for SCAPA • opportunity: make drawings of Brazil type no-till DAP planter for tendering process in Tanzania	SCAPA
	NGOs		
Karatu Development Association (KDA)	• promote crops such as lablab, mucuna, white millet • promote no tillage with cover crops • other activities: gully control, promotion of animal traction, support to women for dairy goats, microfinance for women and non-farm activities, support for safflower production • initially funded by Denmark, now self-funded	• provide seeds (mucuna, lablab) • field days and training • oxen training and introduction of no till implements	SARI
Soil Conservation and Agroforestry Programme, Arusha (SCAPA)	• conservation tillage: sub-soiling, DAP ripping, mulching, cover crops, use of farmyard manure, row spacing and fertilizer • other activities: contour bunds and fodder grasses, tree planting and gully rehabilitation, gender, fish farming, bee keeping, horticulture, water harvesting structure, grazing management, improved stoves • funded by Swedish International Development Cooperation Agency and supported by RELMA	• on-farm demonstration trials in Arusha and Arumeru Districts • data collection and analysis through field days • imported DAP rippers from Zambia through TFA • community development officer organises farmer groups to use ripper in association with sub-soiling, mulching, cover crops and FYM • study tours to Machakos in Kenya	TFA
FARMAfrica	• activities implemented by Babati Rural Development Project: village development planning, animal health, training farmers and extension workers, farmers' participatory research through farmer research groups (crops, pest management, soil fertility, labour saving technologies) • supported by EU and Netherlands	• farmers trained by LAMP on how to operate DAP ripper and sub-soiler • farmer research on soil fertility included cover crops	LAMP Babati, SARI, DALDO Babati, National Beans Programme

APPENDIX IV: CONSERVATION AGRICULTURE INNOVATION SYSTEM BY SECTOR (continued)

Organization	Activities	Methods to promote conservation farming	Linkages with other organizations
	Private sector		
Tanzania Farmers' Service Centre (TFSC)	• tractor sub-soiling and ploughing, and combine harvester hire services • sell agricultural machinery and spare parts • service agricultural machinery • support conservation agriculture research activities, training and demonstration trials • hold workshops and courses on sustainable agriculture, use of agricultural machinery and efficient crop production • initially supported by GTZ, now self-funded; retain a development mandate	• in collaboration with SARI have a demonstration plot with cover crops, minimum/no tillage • provide machinery for demonstration trials, seeds and CA expert support • promote tractor sub-soiling services to farmers (Tsh 60000 per acre)	SARI
Tanganika Farmers' Association (TFA)	• inputs supply: seeds, fertilizer, pesticides, fungicides, hand tools, DAP equipment, sprayers • branches throughout country • membership fee Tsh 15000: receive discount on purchases, access to credit, share in dividend, free advisory services	• sell to members (on credit) and non-members • Babati depot also sells DAP rippers made by Nandra Engineering Works • opportunity: display lablab seeds to create an awareness	manufacturers and suppliers
Nandra Engineering Works Ltd, Moshi	• manufacture DAP rippers, spare parts for rippers and tractors (on request) • also manufacture maize mills, hullers, grain storage tanks, cookers, water tanks	• facilitate group purchases on credit • spare parts for ripper and tractors available directly from workshop or shop in Arusha • opportunity: manufacture no-till direct planter, jab planter	LAMP Babati (rippers) CTP (rippers)
SEAZ Agricultural Equipment Company, Mbeya	• promotes DAP to reduce drudgery and improve livelihoods of smallholder farmers • manufacturers, importers and distributors of various DAP implements and providers of after sales services • produced Mkombozi multipurpose toolbar • train farmers on use of DAP implements • consultancy and advisory services	• re-produced no-till DAP planter from Brazil • sold more than 500 conservation tillage implements (including a ripper attachment for its Mkombozi multipurpose toolbar)	

APPENDIX V: METHODOLOGY FOR QUALITATIVE DATA COLLECTION

Data	Method	Location	Source of farming
Agroecological zones	Semi-structured interview	• Karatu	Key informants: DALDO
Land tenure and land use	Semi-structured interviews	• Karatu • Babati	Key informants: village administration, farmers, LAMP, DALDO
Health	Individual interviews	• Karatu • Babati	Key informants: district medical officers, district maternal mother and child health coordinator, district AIDS coordinators
Labour	Semi-structured interviews	• Karatu (Kilimatembo and Rhotia Kati) • Babati (Singe and Tsamasi)	Key informants and group discussions with women and men farmers Average 13 people per community Total: 53 (17 women, 36 men)
Decision making, traditions and norms	Semi-structured interviews	• Karatu (Kilimatembo and Rhotia Kati) • Babati (Singe and Tsamasi)	Group discussions with key informants: elders, village leaders, extension staff, farmers Average 12 people per community Total: 48 (17 women, 31 men)
Household requirements	Individual interviews	• Karatu • Babati	Farmers (women and men)
Crop patterns	Household profiles	• Karatu • Babati	Farmers (women and men)
Use of inputs	Household profiles and wealth ranking	• Karatu • Babati	Farmers (women and men)
Mechanization	Individual interviews	• Karatu • Babati	Key informants: mechanization officers
Innovation systems	Semi-structured interviews	• Karatu • Babati	Key informants: DALDO, NGO staff, farmers
Wealth ranking	Group discussion. A sample of 100 farmers in each village was selected at given intervals from a list of all HHs in the village and their names were written on cards. The group placed the cards in different wealth groups, according to wealth criteria identified by farmers.	• Karatu (Kilimatembo and Rhotia Kati) • Babati (Singe and Tsamasi)	Mixed group of farmers (women an men), village sub-ward leaders, elders, retired officers, extension workers Average 20 – 25 people per community Total: 85 (41 women, 44 men)
Ranking of cover crops	Identification and ranking of crops/cover crops according to farmers' own criteria.	• Karatu (Kilimatembo) • Babati (Singe and Tsamasi)	Groups of farmers (women and men) Average 20 – 25 people per community Total: 72 (31 women, 41 men)
Evaluation of CA equipment	Ranking of CA equipment according to farmers' own criteria. The equipment was demonstrated to farmers, they operated them and afterwards open group discussions were held.	• Rhotia Kati	24 farmers (16 women, 8 men), majority of whom had already used equipment plus some who had developed an interest after seeing the equipment in use
Discussion on weeds	Identification of the most problematic weeds and their occurrence (displayed on a calendar)	• Karatu (Kilimatembo) • Babati (Singe and Tsamasi)	Groups of farmers (women and men) Average 20 – 25 people per community Total: 72 (31 women, 41 men)
Farmers' evaluation of CA and impact analysis	Semi-structured individual interviews	• Karatu (Kilimatembo and Rhotia Kati) • Babati (Singe and Tsamasi)	All farmers participating in trials

APPENDIX VI: LIVELIHOOD CHARACTERISTICS OF STUDY COMMUNITIES

Table 1: Livelihood Characteristics in Rhotia Kati, Karatu District

Characteristics	Rich (5% HHs)	Medium wealth (15% HHs)	Poor (80% HHs)
Livelihood activities	Business Rent out houses Sell crops Sell livestock and milk	Sell crops Sell livestock and milk	80% work as casual labourers for medium wealth and rich farmers Sell crops
Land (area per HH)	2.5 – 3.2 ha (but may rent in a further 12 ha)	1.6 – 2.4 ha (also have capacity to rent in land)	0.4 – 1.2 ha often rent out land due to need for cash and cultivate small proportion for themselves
Crops grown	Wheat (80% area), maize (20% area), pigeon peas, beans	Wheat, maize, pigeon peas, beans	Maize, beans, pigeon peas
Use of external inputs	40% buy farm inputs (eg herbicides for wheat production, improved maize seeds). Other HHs can afford to buy inputs but pay more attention to off-farm activities	75% buy inputs (especially improved seeds)	Do not buy inputs. In dry years receive seeds from hunger relief programmes
Farm power and implements	Labour: hire for weeding and harvesting DAP: 90% own oxen (use for ploughing and transport) Tractors: majority hire and some own Combine harvesters: hire for wheat harvesting	Labour: hire for weeding and harvesting DAP: majority own oxen and implements Tractors: hire for primary tillage Combine harvesters: hire for wheat harvesting	Labour: Plant in holes using hand hoe (minimum soil disturbance) DAP: Majority has one ox (join with others to form ploughing team and till plots)
Livestock	More than 100 heads of cattle (kept outside village in the lowlands and also give to poor HHs to look after in exchange for milk and manure) 10 – 20 goats	75% have cattle (6 – 10 heads, including oxen) 5 – 6 goats	75% keep 1 – 3 cows on behalf of rich farmers in exchange for milk and manure (kept outside village in search of fodder especially during dry season); heifers are returned to owners very few have goats (1 – 4 animals)
Distribution of FHHs	5%	25%	70%
Farmers participating in study	Nil	1 MHH	4 FHHs

Total number of HHs in community = 815; proportion of FHHs in community = 30% households (and increasing steadily)
Source: Community description during fieldwork

Table 2: Livelihood Characteristics in Kilima Tembo, Karatu District

Characteristics	Rich (5% HHs)	Medium wealth (45% HHs)	Poor (50% HHs)
Livelihood activities	Rent out houses and shops Formal employment Traders, middlemen Sell livestock and milk Sell crops within and outside village	Teachers Run small businesses Traders, middlemen Sell livestock and milk Sell crops within and outside village	Casual labouring Rent out land Sell crops in village No sale of crop residues
Land	More than 4 ha	1.2 – 4 ha rent out land to rich	0.4 – 1.2 ha; rent out land to medium wealth and rich HHs when need cash
Crops grown	Maize, beans, pigeon peas, finger millet, sorghum, sweet potatoes, pumpkins, wheat, barley, sunflower, flowers	Mainly maize and beans Also sweet potatoes, finger millet, pumpkins, pigeon peas	Mainly maize and beans Also sweet potatoes, finger millet, pumpkins, pigeon peas
Use of external inputs	Some use herbicides (for wheat), pesticides (for flowers) Very few used improved wheat seeds	Mainly use improved maize seeds	Very few buy inputs. Only use if given free of charge or participate in research trials or demonstrations
Farm power and implements	DAP: 70% own Tractors: 20% own; 80% hire tractors for primary tillage	Tractors: hire DAP: 70% own draught animals; 40% own ploughs; HHs without animals hire when need arises	100% hand hoe
Livestock	20 – 40 cattle 10% have dairy cows	5 – 10 cattle (majority local breeds) 20% have dairy cows	Chicken A few local cattle Majority keep cattle (1 – 5 head) from wealthier households
Distribution of FHHs	Nil	15%	85%
Farmers participating in study	2 MHHs	1 MHH	1 MHH; 2 FHHs

Total number of HHs in community = 545; proportion of FHHs in community =30% (and increasing steadily)
Source: Community description during fieldwork

APPENDIX VI: LIVELIHOOD CHARACTERISTICS OF STUDY COMMUNITIES (continued)

Table 3: Livelihood Characteristics in Tsamasi, Babati District

Characteristics	Rich (5% HHs)	Medium wealth (35% HHs)	Poor (60% HHs)
Livelihood activities	Sell crops Sell livestock and livestock products Run milling machines, small shops	Sell crops Sell livestock and livestock products Run kiosks	Sell crops (mainly pigeon peas and finger millet; sometimes maize and beans) Sometimes sell chicken Casual labouring
Land	2 – 4 ha Rent in from other groups	0.8 – 2 ha 50% rent in from poor HHs	Less than 0.8 ha some do not own land but rent in from medium wealth group (in return for labour)
Crops grown	Coffee, bananas, maize, beans, pigeon peas, sunflower, vegetables, cassava, sweet potatoes, finger millet	Coffee, bananas, maize, beans, pigeon peas, sunflower, vegetables, cassava, sweet potatoes, finger millet	Maize, beans, pigeon peas, sunflower, vegetables, cassava, sweet potatoes, finger millet
Use of inputs	Few use improved seeds A few apply FYM	Few use improved maize seeds Some apply FYM	Very few use improved seeds No ox carts to transport FYM – a very few apply in fields near homestead
Farm power and implements	Labour: 10% family, 10% reciprocal, 80% hired DAP: 100% own oxen, majority have 2 – 3 ploughs; only one farmer has ox cart Tractor: one owner and others hire	Labour: 30% family, 20% reciprocal, 50% hired DAP: 90% own oxen and 1 – 2 ploughs; a few own ox carts	Labour: 70% family, 30% reciprocal DAP: 10% own oxen; no-one owns ox cart; some HHs hire DAP
Livestock	10 – 20 cattle goats, sheep chicken	5 – 10 cattle goats, sheep chicken	Up to 5 cattle 80% keep livestock owned by richer households chicken
Distribution of FHHs (=100%)	Nil	20%	80%
Farmers participating in study	Nil	1 MHH ! FHH	! MHH ! FHH

Total number of HHs in community = 800; proportion of FHHs in community = 10%
Source: Community description during fieldwork

Table 4: Livelihood Characteristics in Singe, Babati District

Characteristics	Rich (20% HHs)	Medium wealth (50% HHs)	Poor (30% HHs)
Livelihood activities	Sell crops Sell livestock and livestock products Formal employment Small businesses	Sell crops Sell livestock and livestock products Small businesses	75% casual labouring sell chicken and eggs
Land	2 – 8 ha	0.8 – 2 ha	Less than 0.8 ha
Crops grown	Coffee, maize, beans, pigeon peas, lablab, finger millet, bananas	Coffee, maize, pigeon peas, lablab, sorghum, bananas	Maize, beans, pigeon peas, lablab, sunflower, finger millet, sorghum
Use of external inputs	50% used improved seeds, fertilizer and pesticides	50% use improved seeds	Not use
Farm power and implements	Labour: 20% family, 80% hired DAP: hire and own Tractors: hire for land preparation	Labour for weeding: 50% family, 50% hired DAP: own oxen, carts, plough Tractor: hire	Labour: family DAP: join with other HHs to gain access to sufficient oxen and plough
Livestock	100% own cattle (> 10 heads) 10% own dairy cattle 1 – 5 goats and sheep chicken	75% own cattle (up to 10 heads) 20% own dairy cattle 10 – 20 goats chicken	35% keep one cattle owned by other farmers 65% have no cattle up to 5 goats chicken
Distribution of HHs in community	20%	50%	30%
Distribution of FHHs	25%	45%	30%
Farmers participating in study	1 married woman	1 MHH	Nil

Total number of HHs in community = 410; proportion of FHHs in community = 25%
Source: Community description during fieldwork

APPENDIX VII: ON-FARM FIELD TRIAL DATA BY CULTIVATION SYSTEM

Table 1: Karatu District

	Conventional systems (hours per ha)			RTCC systems (hours per ha)		
	Hoe	**DAP**	**Tractor**	**Jab planter (Beginners)**	**Jab planter (hired labour) + DAP knife roller**	**DAP no-till planter**
Number of plots	3	5	2	2	2	1
Land clearance[1]						
Hand + slash + carry	115	56				Not required[2]
Hand + slash + burn			6[3]			
Hand + slash only				48		
DAP knife roller					10	
Herbicide				4[4]	4	
Land preparation + planting						
Hand hoe – digging, planting by hand	120					
DAP – plant by hand behind plough		58				
Tractor - broadcast and incorporate with disc plough			21			
Planting with hand jab planter				345[5]	47[6]	
Planting with no-tillage DAP planter						9[7]
Weeding[8]						
Hand weeding with hoe plus up rooting of weeds	172[9]	74	111[10]	107	54	25[11]
Harvesting						
Up-rooting by hand	53	48	57	34	13	19
Total (hours per ha)	**460**	**236**	**195**	**538**	**128**	**53**
Yields (beans) (kg/ha equivalents)	**577**	**938**	**1176**	**703**[12]	**305**[13]	**835**

[1] In the RTCC system land clearance can be done either done by slashing/chopping down the weeds and cover crops by panga or by DAP knife roller. Also in the RTCC system one herbicide spraying was applied due to heavy infestation of small weeds emerging after the heavy rains. Conventionally land clearance means: slash and carry or slash and burn (although the latter is illegal).

[2] This field was left fallow in the previous season. The field is located along a throughway, hence livestock passed by regularly and had eaten the emerging weeds and grasses and no land clearance was required.

[3] Slash and burn is banned but is still used sometimes. It has a labour saving benefit.

[4] The labour data recorded are only for the time spent for spraying. The time for fetching clean water for spraying is not included. For spraying one acre using a knapsack sprayer, approximately 80 litres of clean water are needed.

[5] This was the first season for this group of farmers to work with the jab planter, they needed time to practice hence high labour data for beginners. Additionally this group consisted of middle aged and elderly FHH.

[6] This group of young men (in their 30s) specialised in using the jab planter and they were hired to do the planting. They gained good work performance and needed much less time compared to the beginners.

[7] The Brazil type DAP planter was used by one innovator farmer with considerable labour saving effect. The handling requires some training and commitment.

[8] Ideally the effort for weeding should be reduced in the RTCC system. Due to the envisaged soil cover through crop residues, stover and cover crops the weeds are suppressed as they lack sufficient sun-light. Sometimes it is sufficient only to do up-rooting. In other cases scrapping by hand hoe needs to be done to eliminate stubborn weeds. However, the trend shows that less labour for weeding is required as the farmers' awareness for soil cover is raised.

[9] The conventional hand hoe farming system has traditionally very high labour requirement for weeding (compared to conventional DAP or tractor system).

[10] This field had a heavy infestation of weeds. More than three weedings by hand hoe were required plus uprooting.

[11] There was little weed infestation and up-rooting was required only occasionally

[12] This group planted in mid November 2002; immediately after regular rains and supportive climatic conditions lead into a 'bumper harvest'.

[13] This group planted early (mid October 2002) followed by a three weeks dry spell; consequently the yields were lower than average in this season.

APPENDIX VII: ON-FARM FIELD TRIAL DATA BY CULTIVATION SYSTEM (continued)

Table 2: Babati District

	Conventional systems (hours per ha)		RTCC systems (hours per ha)			
	Hoe	DAP	DAP Ripper + hand plant + herbicide	DAP ripper with planter + herbicide	Tractor sub-soiling + vibroflex + DAP plough	Tractor sub-soiling + DAP ripper planter + herbicide
Number of plots	1	2	2	1	1	1
Season	Short rains	Short rains	Long rains	Long rains	Long rains	Long rains
Land clearance[1]						
Hand hoe + slash with panga + carry	30	56	13	18	13	12
Herbicide application	-	-	4	4	4	4
Land preparation[2]						
Hand hoe – digging	113					
DAP – ploughing		53				
DAP – ripping			18[3]	18		
Tractor – sub-soiling					4	3
Tractor - vibroflex					1.5	
Farmyard manure (FYM) application[4]						
FYM along furrows						24
Planting[5]						
Planting with hand hoe - digging holes	120					
Planting behind DAP plough		61			44	
Planting (maize + cover crop)[6]			62			
Planting with ripper planter attachment[7]				9		9
Cover crops						
Inter row hand planting of cover crop				63		17
Weeding[8]						
Weeding with hand hoe + up rooting	85	65	67	78	66	16
Pest control						
Hand picking	38					
Harvest						
By hand	71	48	49	28	62	30
Total (hours per ha)	**457**	**283**	**213**	**218**	**195**	**115**
Yields (beans/maize) [kg/ha equivalents]	**499 (beans)**	**407 (beans)**	**1322 (maize)**	**1469 (maize)**	**1503 (maize)**	**2009 (maize)**

1 Depending on the previous crop, the stage of weed infestation, and the general condition of the plot land clearance is done by hand using hand hoe, slasher or panga. Some farmers used herbicides.
2 In Babati, land preparation is an operation which is done separately from planting.
3 The time for ripping with DAP is considerable lower than with the mouldboard plough and only one pair of oxen is required compared to two pairs for the mouldboard plough.
4 Only one farmer applied FYM; he hired a lorry to bring the manure to the field and hired labour to distribute it along the ripper furrows
5 In the DAP ripper system planting is either done by hand (in the prepared ripper furrow) as soon as the rains start or using the ripper a second time and planting by hand in the new ripper furrow. A third option is to use the ripper attachment which is very labour efficient, requiring only two instead of three persons.
6 By hand following the existing ripper furrow
7 In new ripper furrow (only maize)
8 In the conservation tillage plots which used herbicides for land clearance, the amount of labour for weeding was considerably lower than other systems.

APPENDIX VIII: GENDER DIVISION OF LABOUR BY CULTIVATION SYSTEM

Table 1: Percentage Distribution of Labour Inputs between Women and Men by Activity

	Activity											
	Land clearance		Land preparation		Planting		Weeding		Harvesting		Herbicide application	
	women	men	women	men	women	men	women	men	women	men	women	men
Karatu conventional tillage												
Hoe (FHH)	45	55	-	-	75	25	85	15	65	35	-	-
DAP (FHH)	50	50	-	100	100	-	95	5	75	25	-	-
DAP (MHH)	100	-	-	100	25	75	60	40	25	75	-	-
Tractor (MHH)	-	100	-	100	-	100	55	45	40	60	-	-
Karatu RTCC												
Jab planters beginners (FHH)	100	-	-	-	85	15	85	15	75	25	-	100
Jab planters hired labour (MHH)	-	100	-	-	25	75	50	50	15	85	-	100
DAP no-till planter (MHH)	-	-	-	-	-	100	-	100	25	75	-	-
Babati conventional tillage												
Hoe (MHH)	-	100	-	100	50	50	35	65	50	50	-	-
DAP (FHH)	75	25	-	100	35	65	45	55	90	10	-	-
Babati RTCC												
DAP ripper (FHH)	-	100	-	100	35	65	25	75	75	25	-	100
DAP ripper + planter (MHH)	-	100	-	100	15	85	15	85	-	100	-	100
Sub-soiler + vibroflex + DAP (FHH)	-	100	-	100	-	100	-	100	60	40	-	-
Sub-soiler + DAP ripper (MHH)	-	100	-	100	-	100	-	100	-	100	-	100

Percentages rounded to nearest 5%

APPENDIX IX: GROSS MARGINS BY CULTIVATION SYSTEM

Table 1: Gross Margins for Conventional Farmers, Short Rains, Karatu

			Conventional hoe		Conventional DAP		Conventional tractor	
	unit	Tsh/unit	unit/ha	total Tsh/ha	unit/ha	total Tsh/ha	unit/ha	total Tsh/ha
YIELD (beans)	kg	250	577	144250	938	234500	1162	290500
INPUTS								
seeds	kg	300	74	22200	74	22200	74	22200
Sacks	per 10 kg	100	58	5770	94	9380	116	11620
GROSS MARGIN				**116280**		**202920**		**256680**
LABOUR AND FARM POWER INPUTS								
land clearance by hand	day	1000	19.2	19167	9.3	9333	1.0	1000
planting by hand	day	1000	17.1	17143	0.0	0	0.0	0
DAP ploughing	ha	20000	0.0		6.0	20000	0.0	0
tractor ploughing	ha	30000	0.0		0.0	0	1.0	30000
planting behind DAP/tractor	day	500	0.0		5.6	2800	3.2	1600
hand weeding	day	500	43.0	21500	18.5	9250	27.8	13875
harvest	day	500	13.3	6625	12.0	6000	14.3	7125
Total				64435		47383		53600
MARGIN AFTER LABOUR AND FARM POWER COSTS				**51845**		**155537**		**203080**
ANALYSIS								
Number of labour days/ha			93		51		47	
Returns to labour (GM/day)			1256		3945		5438	
Returns to labour (kg/day)			6		18		25	

Table 2: Gross Margins for RTCC Farmers, Short Rains, Karatu

			Jab planter (beginners)		Jab planter (hired labour)		No till + DAP planter	
	unit	Tsh/unit	unit/ha	total Tsh/ha	unit/ha	total Tsh/ha	unit/ha	total Tsh/ha
YIELD (beans)	kg	250	702	175500	305	76250	835	208750
INPUTS								
seeds	kg	300	74	22200	74	22200	74	22200
herbicide		8000	2.5	20000	2.5	20000	0	
Sacks	per 10 kg	100	70	7020	31	3050	84	8350
GROSS MARGIN				**126280**		**31000**		**178200**
LABOUR AND FARM POWER INPUTS								
DAP knife roller	ha	10000	0.0		2.0	10000	0.0	
herbicide application		1000	1.0	1000	1.0	1000	0.0	
land clearance by hand	day	1000	8.0	8000	0.0		0.0	
planting with jab planter	day	1000	49.3	49286	6.7	6714	0.0	0
planting with DAP planter	ha	7500	0.0		0.0		2.0	7500
hand weeding	day	500	26.8	13375	13.5	6750	6.3	3125
harvest	day	500	8.5	4250	3.3	1625	4.8	2375
Total				75911		26089		13000
MARGIN AFTER LABOUR AND FARM POWER COSTS				**50369**		**4911**		**165200**
ANALYSIS								
Number of labour days/ha			94		26		13	
Returns to labour (GM/day)			1350		1171		13708	
Returns to labour (kg/day)			8		12		64	

APPENDIX IX: GROSS MARGINS BY CULTIVATION SYSTEM (continued)

Table 3: Gross Margins for Conventional Farmers, Short Rains, Babati

			Conventional hoe		Conventional DAP	
	unit	Tsh/unit	unit/ha	total Tsh/ha	unit/ha	total Tsh/ha
YIELD (beans)	kg	250	499	124750	407	101750
INPUTS						
seeds	kg	300	74	22200	74	22200
sacks	per 10 kg	100	50	4990	41	4070
GROSS MARGIN				**97560**		**75480**
LABOUR AND FARM POWER INPUTS						
land clearance by hand	day	1000	5.0	5000	9.3	9333
digging by hand	day	1000	18.8	18833	0.0	
planting by hand	day	1000	17.1	17143	0.0	
DAP ploughing	ha	15000	0.0		18.6	30000
DAP ripping	ha	13500	0.0		0.0	
planting behind DAP plough/ripper	day	500	0.0		4.0	2000
hand weeding	day	500	21.3	10625	16.3	8125
hand picking of pests	day	500	6.3	3167	0.0	
harvest	day	500	17.8	8875	12.0	6000
Total				63643		55458
MARGIN AFTER LABOUR AND FARM POWER COSTS				**33917**		**20022**

ANALYSIS

Number of labour days/ha		86	60
Returns to labour (GM/day)		1130	1254
Returns to labour (kg/day)		6	7

Table 4: Gross Margins for DAP System, Long Rains, Babati

			DAP ripper + herbicide		DAP ripper + planter + herbicide	
	unit	Tsh/unit	unit/ha	total Tsh/ha	unit/ha	total Tsh/ha
YIELD (maize)	kg	150	1322	198300	1469	220350
INPUTS						
seeds	kg	1400	25	35000	25	35000
herbicide		8000	2.5	20000	2.5	20000
sacks	per 10 kg	100	132	13220	147	14690
GROSS MARGIN				**130080**		**150660**
LABOUR AND FARM POWER INPUTS						
land clearance by hand	day	1000	2.2	2167	3.0	3000
herbicide application	day	1000	1.0	1000	1.0	1000
DAP ripping	ha	13500	3.6	13500	3.6	13500
planting behind ripper	day	500	12.4	6200	0.0	0
planting with ripper attachment	ha	13500	0.0		1.8	13500
cover crop	day	500	0.0		12.6	6300
hand weeding	day	500	16.8	8375	19.5	9750
harvest	day	500	12.3	6125	7.0	3500
Total				37367		50550
MARGIN AFTER LABOUR AND FARM POWER COSTS				**92713**		**100110**

ANALYSIS

Number of labour days/ha		48	49
Returns to labour (GM/day)		2701	3106
Returns to labour (kg/day)		27	30

APPENDIX IX: GROSS MARGINS BY CULTIVATION SYSTEM (continued)

Table 5: Gross Margins for Tractor and DAP System, Long Rains, Babati

			Sub-soiler + vibroflex + DAP plough		Sub-soiler + DAP ripper + planter + cover crop + herbicide	
	unit	**Tsh/unit**	**unit/ha**	**total Tsh/ha**	**unit/ha**	**total Tsh/ha**
YIELD (maize)	kg	150	1503	225450	2009	301350
INPUTS						
seeds	kg	1400	25	35000	25	35000
herbicide		8000	2.5	20000	2.5	20000
sacks	per 10 kg	100	150	15030	201	20090
GROSS MARGIN				**175420**		**246260**
LABOUR AND FARM POWER INPUTS						
land clearance by hand	day	1000	2.2	2167	2.0	2000
herbicide application	day	1000	1.0	1000	1.0	1000
tractor sub-soiling	ha	12333	1.0	12333	1.0	12333
tractor vibroflex	ha	20000	1.0	20000	0.0	0
application farmyard manure	ha	500	0.0		4.0	2000
DAP ploughing	ha	15000	5.9	15000	0.0	
planting behind DAP plough	day	500	2.9	1452	0.0	
planting with ripper attachment	ha	13500	0.0		1.8	13500
inter-row planting cover crops	day	500	0.0		3.4	1700
hand weeding	day	500	16.5	8250	4.0	2000
harvest	day	500	15.5	7750	7.5	3750
Total				67952		38283
MARGIN AFTER LABOUR AND FARM POWER COSTS				**107468**		**207977**

ANALYSIS

Number of labour days/ha		46	25
Returns to labour (GM/day)		3817	9970
Returns to labour (kg/day)		33	81

APPENDIX X: LABOUR AND FARM POWER WORK RATES AND COSTS

Table 1: Daily Labour Work Rates and Costs

Activity	Unit	Tsh per day
Land clearance	6 hours/day	1000
Digging	6 hours/day	1000
Planting by hand	7 hours/day	1000
Planting by jab planter	7 hours/day	1000
Planting by hand behind DAP plough/ripper/tractor	5 hours/day	500
Weeding	4 hours/day	500
Hand picking of pests	6 hours/day	500
Harvesting	4 hours/day	500
Spraying herbicide (including use of sprayer)	application	1000

Table 2: DAP and Tractor Work Rates and Hire Charges

Activity	Labour days/ha	Tsh per acre	Tsh per ha equivalent
DAP knife roller (2 oxen, 2 operators) Karatu	2	4000	10000
DAP plough (4 oxen, 2 operators) Karatu	6	8000	20000
DAP plough (4 oxen, 2 operators) Babati	5	6000	15000
DAP ripper (2 oxen, 2 operators) Babati	3.6	5500	13500
DAP planter	2	3000	7500
Tractor plough (driver, assistant, fuel)	1	12000	30000
Tractor + vibroflex (2 operators) Babati	1	8000	20000
DAP sub-soiler (6 – 8 oxen)		8000	20000
Tractor sub-soiler *	1	15000	37000

** In Babati farmers paid two thirds of cost, one third paid by LAMP; benefits last for three years*

APPENDIX XI: FARMERS' EVALUATION OF COVER CROPS, BABATI DISTRICT

Table 1: Farmers' Evaluation of Cover Crops by Various Criteria, Singe

Criteria	Cover crops	Crops traditionally inter-cropped		
	lablab	pumpkins	kalabash	finger millet
food	3	5	1	5
market	5	2	2	5
price of seed	3	5	5	3
soil fertility	5	4	4	1
soil erosion control	4	5	5	3
moisture conservation	4	5	5	1
weed control	5	5	4	3
Total	**29**	**31**	**26**	**21**

Maximum of 5 points allocated for each characteristic; the higher the points, the better the characteristic
Source: Women and men farmers, Singe

Table 2: Farmers' Evaluation of Cover Crops by Various Criteria, Tsamasi

Criteria	Cover crops	Crops traditionally inter-cropped		
	lablab	pumpkins	cowpea	water melon
food	4	5	4	5
market	5	2	4	3
price of seed	1	5	2	1
soil fertility	5	5	3	3
moisture conservation	4	5	3	3
weed control	5	5	3	3
Total	**24**	**27**	**19**	**18**

Maximum of 5 points allocated for each characteristic; the higher the points, the better the characteristic
Source: Women and men farmers, Tsamasi

APPENDIX XII: PRICES OF FARM TOOLS

Tool	Description	Trade mark	Country of manufacture	Price (TShs)
HAND TOOLS				
hoe	2.5 lb	Cock	China	1700
hoe	1.5 lb	Cock	India	1500
hoe	3 lb, no neck	Chillington Crocodile	China	2000
hoe	3 lb	genuine Cock	China	1500 - 2200
hoe	3 lb	counterfeit Cock	China	1800
hoe	small, no neck	Cock	China	1700
hoe	small	Lasher	South Africa	2000
hoe	half moon	Cock	China	4500
hoe	half moon	Lion	China	3500
hoe	Mbalamwezi (moon)	Mbeya Industries	Tanzania	3000
tiny hoe with spike	with handle	Blacksmith	Tanzania	1000
forked hoe	9" tines	Cock	China	3500
forked hoe		Great Wall	China	3500 - 4000
jembe handle	1 metre		Tanzania	500
hoe + fork hoe	metal handle	Kilimanjaro label	Tanzania	2600
panga		Chillington	China	1400 - 1500
panga	16"	Chillington	China	1000
panga	poly handle	Lasher	South Africa	2000-2500
slasher			China	1500
slasher	poly handle	Lasher	South Africa	2000
file			China/India	750
sickle	10"	Lasher	South Africa	2600
sickle	10"	Cock	China	800
sickle	8", 16"	Dinosaur		1000
rake			China	2200 - 2500
axe head	2.5 - 3.5 lbs	Diamond, Dinosaur	China	2000 - 2500
pick axe		Chillington Crocodile		3500
shovel		Flying Swallow	China	2500
wheelbarrow				20000-30000
knapsack sprayer	15 litre	Solo	German license	65000
knapsack sprayer	15 litre	CP 15		50000
jab planter			Brazil	15000
jab planter		CARMATEC	Tanzania	10000
DAP EQUIPMENT				
plough		UFI	Tanzania	55000 - 60000
plough	Cossul		India	47000
plough	Mkombozi		Tanzania	30000
chains				4000
no-till planter			Brazil	120000
knife roller			Brazil	300000
ripper tine attachment		Nandra	Tanzania	60000
ripper planter		Nandra	Tanzania	75000
IRRIGATION EQUIPMENT				
hand pump		ApproTEC		18000
treadle pump	Money maker plus	ApproTEC		49500
treadle pump	Super money maker	ApproTEC		74950
AGRO-CHEMICALS				
herbicides	1 litre Roundup	Monsanto	Kenya	8000
herbicides	2 4 D			5000

Source: prices collected from shops in Karatu and Babati, the open market in Karatu town, and Karatu's monthly market (latter had better range of DAP tools). There was little variation in prices between different sources although farmers were said to buy more in the market.

TFA: Tanganika Farmers' Association
UFI: Ubungo Farm Implements (manufacturers), Dar es Salaam
ApproTEC: International NGO working in Kenya and Tanzania