CONSERVATION AGRICULTURE IN BABATI DISTRICT, TANZANIA

Impacts of Conservation Agriculture for small-scale farmers and methods for increasing soil fertility

Master of Science Thesis
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ABSTRACT

Title: Conservation Agriculture in Babati District, Tanzania
Impacts of Conservation Agriculture for small-scale farmers and methods for increasing soil fertility

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Keywords: Tanzania, Babati District, Conservation Agriculture, Reduced tillage, Cover crops, Soil fertility, *Faidherbia albida*, Rural development

People mainly rely on the agricultural sector in the poorest countries of the world. An increased agricultural production can therefore have a great impact on individuals as well as on whole communities in many countries. A majority of the Tanzanians live in rural areas and rely on the agricultural sector. Today the agricultural production in Tanzania is rather low and Conservation Agriculture (CA) is a concept that is promoted as a way forward for small-scale farmers in Tanzania.

This study that was carried out in Babati District, Tanzania and was one out of several studies that were conducted on CA in Africa before the ”Third World Congress on Conservation Agriculture”. The aim of the studies was to improve the understanding and documentation of past and current CA experiences in Africa.

This study aims to describe the CA-related practises that have been introduced in Babati District and why they had been introduced. It also aims to describe the reasons why farmers choose to adopt or not adopt CA practice in their farming and the impacts CA has had on small-scale farmers livelihood and on the environment.

The last decade several new agricultural practises have been introduced in the district, of which a number can be said to be CA-practises. The introduced agriculture methods have had a positive effect on yields, work load and environment. The small-scale-farmers livelihoods have also improved in Babati District as an outcome of the new agricultural methods. The diffusion of the introduced methods was limited due to among others availability of implements, economical factors and finite dissemination of knowledge.

The low soil fertility was a limiting factor of the production in the district and recycling of plant nutrients to the arable land was low. In the study, soils from three different cultivation systems have been compared to investigate how different treatments have influenced soil fertility. Farm yard manure and intercropping with legumes showed to improve the fertility and application of rock phosphate increased availability of phosphor and increased soil pH. When only rock phosphate was applied production rate were low and amount of nutrients was decreasing or showed no significant change. Intercropping under leguminous *Faidherbia albida* gave the highest maize yields and also showed the highest level of P and N.

REFERAT

Titel: Conservation Agriculture i Babati District, Tanzania
Effekterna av Conservation Agriculture för småskaliga jordbrukare och metoder för ökad markbördighet

Författare: Fredrik Löfstrand
Medförfattare: Martin Löfstrand
Handledare: Professor Erasmus Otabbong

Nyckelord: Tanzania, Babati District, Conservation Agriculture, Reduced tillage, Cover crops, Soil fertility, *Faidherbia albida*, Rural development

Jordbruketsektorn är den viktigaste inkomstkällan för människor i de fattigare länderna och en ökad jordbrukproduktion innebär därför ofta mycket för människor och samhället i dessa länder. I Tanzania lever majoriteten av befolkningen på landsbygden och försörjer sig utav jordbruket. Produktionsnivån är ofta låg och Conservation Agriculture (CA) är ett koncept som nu lanseras för att förbättra det småskaliga jordbruket i Tanzania.

Denna studie utfördes i Babati District, Tanzania, och var en av flera studier som utförts kring CA i Afrika inför ”Third World Congress on Conservation Agriculture”. Målsättningen med studierna var att öka förståelsen och dokumentationen kring de erfarenheter som finns beträffande CA i Afrika.

Syftet för denna studie var att beskriva de CA-relaterade teknologier som hade introducerats i Babati District och anledningen till introduceringen av dessa. Syftet var också att beskriva orsakerna till varför jordbrukare valt att använda eller inte använda CA samt vilka effekter CA haft för jordbrukares försörjning och på miljön.

De senaste decenniet hade en rad nya brukningsmetoder introducerats i distriktet, varav ett antal kan sägas vara CA-metoder. De introducerade brukningsmetoderna har haft en positiv effekt på skördar, arbetsbörda och miljö. Småbrukarnas livssituation har också förbättrats i Babati District tillföljd av de nya brukningsmetoderna. Utbredningen av de introducerade brukninsmetoderna var begränsad till följd av bland annat tillgång på redskap och utsäde, ekonomiska faktorer samt begränsad utbredning av kunskap.

Den låga markbördigheten var en begränsande faktor för produktionen i distriktet och återförandet av växtnäringsämnen till åkermarken var låg. I studien har jordar från tre olika odlingssystem jämförts för att se hur olika behanlingarna påverkat markens bördighet. Stallgödsel och samodling med ärtväxter kunde förbättra markens bördighet och tillförsel av råfosfat ökade tillgängligheten av fosfor och höjde markens pH. Skördenivånerna var låga i det fall då enbart råfosfat tillförts och mängden näringsämnen hade minskat eller visade ingen signifikanta förändringar. Samodling med *Faidherbia albida* (en baljväxt) gav de högsta majsskördarna och tillgången på fosfor och kväve var också högst i detta odlingssystem.

ACKNOWLEDGEMENTS

First of all we would like to thank the people in Babati District, Tanzania, that have been our colleges through out the study and that have shared their time, knowledge and experiences with us. - Your help have been invaluable.

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LIST OF ABBREVIATIONS

ACT	Africa Conservation Tillage Network
AEZ	Agro-Ecological Zone
BAEEP	Babati Agricultural and Environmental Education Project
BRDP	Babati Rural Development Project
CA	Conservation Agriculture
CFP	Community Forestry Programme
CS	Case Study
CIRAD	French Agricultural Research Centre for International Development
DALDO	District Agriculture and Livestock Department Officer
DLF	Dry Land Farming
DPO	District Planning Officer
EU	European Union
FA	FARMAfrica
FAO	Food and Agriculture Organization of the United Nations
FFS	Farmer Field School
FIDE	Friends In Development Trust Fund
FTP	Forest Trees and People Project
FYM	Farm Yard Manure
IATC	Integrated Agroforestry Training Centre
ICRAF	World Agroforestry Centre
KTH	Royal Institute of Technology
LAMP	Land Management Programme
LHS	Stockholm Institute of Education
MFS	Minor Field Study
NAEP-II	National Agricultural Extension Project
NALERP	National Agricultural and Livestock Extension Rehabilitation Project
O&OD	Opportunity and Obstacles for Development
RELMA	Regional Land Management Unit
SARI	Selian Agriculture Research Institute
Sida	Swedish International Development Agency
SLU	Swedish University of Agricultural Science
SMS	Subject Matter Specialist
TFA	Tanganyika Farmers Association
TOBRA	Toggenburg Breeders' Association
T&V	Training and Visit

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1. INTRODUCTION

In June 2005 we, Fredrik Löfstrand and Martin Löfstrand[1], got the opportunity to do a Minor Field Study (MFS) about Conservation Agriculture (CA) in Babati District, Tanzania. Fredrik is an agronomy student (plant & soil science) at the Swedish University of Agricultural Science (SLU), Uppsala and Martin is a student at the level of a master's degree of science in engineering at the Royal Institute of Technology (KTH) and of education at the Stockholm Institute of Education (LHS), both situated in Stockholm.

Hearing about the Case Studies (CS) that were to be conducted on CA in East Africa, we became interested in participating and believed it could be interesting and give us valuable experiences of rural and agricultural development work and research. We believe our different academic disciplines would be an asset and strength in the study that was to be both related to agriculture technical issues and to knowledge production and transfer. The study was to result in a master thesis in Agronomy for Fredrik and a thesis at C-level in Pedagogy for Martin. The study was funded through a MFS scholarship that we received from SLU External Relations and locally supported by Regional Land Management Unit (RELMA) in World Agroforestry Centre (ICRAF).

It constituted on out of as series of about ten studies that was carried out in various African countries under an arrangement between RELMA in ICRAF, CIRAD and FAO under CIRAD's coordination and compilation for the 3rd World Congress on Conservation Agriculture hosted by ACT, Ministry of Agriculture in Kenya and NEPAD in Nairobi in Oct 2005. This report is the result of the field study. The report is divided into chapters that can be related to our different disciplines. For each one of these chapters, the author is mentioned. When no author is specified for a chapter, we both assume responsibility for the text. Due to differing time schedules for examination at our institutions and due to our different areas of specialization the report will be presented in two slightly different versions with differing objectives and research questions.

[1] M. Löfstrand report: *Conservation Agriculture in Babati District, Tanzania The Impacts of Conservation Agriculture for Small-scale farmers – how it is taught, learnt and adopted* is published at Stockholm Institute of Education, Department of Social and Cultural Studies in Education, 2005

2. BACKGROUND

"Make hunger history now" is a statement appearing all around the world. An almost infinite number of governments, organizations and individuals are involved in the fight against poverty through projects and programs that are to strengthen rural people's livelihoods. In the world's poorest countries, people mainly make their living through agriculture. Therefore an increased agricultural production can have an important impact on in many countries, both for individuals as well as on whole communities, not least in Sub-Saharan countries. Tanzania is no exception, a majority of the Tanzanians live in rural areas and rely on agricultural production. Generally, agricultural productivity in Tanzania is low, being constrained by low soil fertility, erratic and unreliable rainfall, and poor production techniques (Shetto et al., 2001). CA is now promoted in Tanzania as an instrument for a sustainable and productive agriculture.

2.1 CASE STUDY

This study – carried out in Babati District in Northern Tanzania – is one of several case studies conducted in Africa on CA during 2005. The framework[2] for the studies were planned by the Food and Agriculture Organization of the United Nations (FAO), the French Agricultural Research Centre for International Development (CIRAD), the RELMA in ICRAF and the African Conservation Tillage network (ACT**)**.

The major objectives of the case studies were to improve the understanding and documentation of past and current CA experiences. It was envisioned that these case studies would serve as a solid basis for developing inputs (such as posters, papers and oral presentations) to be shared during the Third World Congress on Conservation Agriculture in Nairobi, October 2005.

2.1.1 Third World Congress on Conservation Agriculture

The Third World Congress on Conservation Agriculture will be held in Nairobi in October 2005. The aim of the congress is to share and expose experiences and lessons noted worldwide on the role of CA in enhancing rural livelihoods in diverse environments. The expectation is that this can contribute to enhancing the promotion/adoption of CA as a production means that concurrently ensures food security, economic benefits and global environmental benefits, including biodiversity and a cleaner environment. (ACT, 2005)

2.2 CONVENTIONAL AGRICULTURE

The mechanisation rate of the agriculture is relatively high in Babati District compared to other parts of Tanzania and the use of tractor and oxen for land preparation is common. Previously, advice from the extension service to the farmers was to plough two to three times before planting to prepare a good sow bed and control weeds. In Babati District application of manure and other fertilisers is low leading to depletion of the soils. The first rains of the agricultural year are used for

[2] See Appendix IX for a shortened version of the Case Study Framework.

ploughing, as the soil has to be moist (soft) before the farmer can prepare the land. Ploughing has also often been done up and down the slopes as the fields often are divided in narrow strips on the hill side. The sowing is done zigzag with hand hoe and/or plough. Weeding is normally done manually (twice with hand hoe). Little organic matter is left in the field and after harvest farmers use the crop residues as fodder or fuel. The livestock often graze in the fields after harvest or the crop residues are collected and transported from the field and then used as fodder.

According to Benites and Ashburner (2003), one of the main causes of land degradation is the use of plough-based and hoe-based agricultural practices. These practices make soil become denser and more compact and make organic matter content decrease, while water runoff and soil erosion increase. An intensive tillage can destroy soil aggregates or clods and make the soil more vulnerable to erosion (Celander et al., 2003).

2.3 THE CONCEPT OF CONSERVATION AGRICULTURE

CA is based on three principles – minimum soil disturbance, permanent soil cover and crop rotation/association, box 2.1. CA should improve, conserve and use natural resources in a more efficient way through integrated management of available soil, water and biological resources, in combination with external inputs (FAO, 2005). The impacts of CA have been markedly positive both in agricultural, environmental, economic and social terms (Garcia-Torres et al., 2003 and Bishop-Sambrook et al., 2004). CA is also often stated to be labour-saving and presented as a potential solution to farm power shortages.

- **Minimum soil disturbance** = ´zero tillage = no tillage = direct planting
- **Permanent soil cover** with the crop itself, cover crops, residues and/or mulch
- **Crop rotation/associations** through crop sequences, intercropping, relay cropping and/or mixed crops

Box 2:1. The three principles of Conservation Agriculture

The full-blown CA (when a farmer uses all the three principles of CA) may not be achievable in the short-term for the farmer and might also be hard to find in Babati District. Table 2:1 illustrates how Conservation Agriculture can be characterized as opposed to Non Conservation Agriculture (Triomphe, 2005).

Table 2:1. Conservation Agriculture vs. Non Conservation Agriculture practise

Practises within the concept of CA	**Practices outside the concept of CA**
Sub-soiling/Chisel ploughing	
Ripping	Ploughing (Disc/mouldboard plough) Harrowing
Tied ridges	Ploughing/Harrowing
Vibro-flex cultivator	Roller tillers
Pitting	Ploughing/Harrowing
Direct seeding	Planting after plough
Crop rotation	Mono-cropping
Contours	Cultivation on sloping land
Cover crops	Incorporating green manure
Intercropping	Mono-cropping
Mulch	Removing residues Incorporation of mulch
Partial removal of crop residues	Crop residues burnt or used as fodder
Up-rooting and leaving weeds on the soil surface	Up-rooting weeds and removing them from the field
Agroforestry	Mono-cropping
Zero-grazing	Post-harvest grazing
Improved pasture	Crop residues as fodder

(Adapted from B. Triomphe, 2005 revised by F. Löfstrand)

3 STUDY METHODS

The main part of the study was done as a field study in Babati District, Tanzania.
The field study was carried out in close cooperation with a team, the Case Study team (CS-team) consisting of subject matter specialists (SMS) from the district agriculture department in Babati. The CS-team consisted of Mr. Elley Simon Mbise, Mr. Anatoly M. Pomonhi, Mr. Patrick N. Msabaha and Mr. Edger Lyakurwa. Here follows a description of the methods that was used during the field study.

3.1 LITERATURE REVIEW

Literature was collected and read before, during and after the field study. To prepare for the field study in Babati District we read several reports from prior research and case studies done in Babati District and on CA. We also read material on methods on development research as help in planning our field study methods. During the study literature were collected and read with the aim to get to learn more about the CA history in Babati District and to learn what different organisations, programs and institutions concerning CA diffusion had done. The collected literatures were mainly annual reports from the organisations and institutions that we came in contact with and statistic material from the district counsel.

3.2 IDENTIFICATION OF RELEVANT INSTITUTIONS

To learn what had been done in the past and what was going on concerning CA related activities in Babati District we wanted to identify and meet all relevant institutions, programs and Non-Governmental Organisations (NGOs) that had been and/or is active in the agricultural sector. This identification we did together with the CS-team.

3.3 SELECTION OF WARDS

Three wards were selected for the study during a meeting with the CS-team. The wards were chosen to cover different agro-ecological zones. The wards were also chosen due to their different experience of CA.

3.4 SELECTION OF FARMERS

Approximately five farmers were interviewed in each ward. The farmers were selected on five criterions, table 3.1 that were set by the CS-team and then send to village extension officers that made the selection of farmers. In one village the team also decided to send one farmer to get another farmer that had not been in any agricultural training. Three interviews were also held with farmers selected due to their successful CA practices.

Table 3:1. Criteria for the selection of farmers, a farmer can belong to more than one group.

Key farmers	Farmers that have been in training groups and that are practising CA
Female headed farms	Farms that are managed by a female farmer
Male headed farms	Farms that are managed by a male farmer
Young farmers	Farms that are managed by a young farmer
Lagged farmers	Farmers that are not practising CA

3.5 FIELD VISITS

Field visits were made through out the study. Farmer's fields, research stations, farming training centres, demonstration fields and local markets were visited. We also visited an agricultural exhibition on the national farmers' day.

3.6 INTERVIEWS

Interviews were held with various informants and stakeholders. Interviews with farmers, village leaders and elders were done by us together with district SMSs that acted as interpreters during the interviews. Interviews with key-informants and stakeholders that spoke English were done by us alone. The length of the interviews varied from one to two hours.

List of key informants and stakeholders interviewed

- District Agriculture and Livestock Department Officer (DALDO)
- District Planning Officer (DPO)
- District Subject Matter Specialists
- Farmer groups
- Individual farmers (Totally 24 interviews were held with individual farmers)
- NGO directors and staff
- Primary school head teacher and subject teachers
- Village leaders and elders
- Village extension officers

3.6.1 Interview guidelines

During semi-structured interviews with individual farmers a guideline and a checklist were used[3]. The guideline consisted of a Farm sketch-map, time-line and a cropping calendar. Later in the study after discussion with the team a decision was made to do farmer interviews without some of the tools mentioned.

Semi-structured interview was also conducted with other key-informants and stakeholders and questionnaires and guidelines were prepared before each interview occasion.

[3] See Appendix I for the farmer interview guideline and checklist

3.6.2 Farm sketch

Farm sketches were used as a tool to describe the farm and the practice on a certain field.

3.6.3 Timeline

The timeline were used as a tool to describe eventually changes that had occurred on the farm and in the agricultural practice, when the changes had occurred and why.

3.6.4 Crop calendar / Seasonal calendar

The cropping calendar were used as a tool to get information about the yearly work on the farm, when, how and by whom the work was done.

3.6.5 Documentation during interviews

During interviews notes were taken by hand, the notes and thoughts from each interview were rewritten during the evening the same day.

3.7 FARMER/VILLAGE-LEADER MEETING

During the first day in each ward meetings together with farmers, the village extension officer and village leaders were held to give information about our study and our reason of visiting them and to get information about the ward.

3.8 QUESTIONNAIRE FOR EXTENSION OFFICERS

A questionnaire[4] was prepared and distributed to 25 village extension officers in Babati District. One aim with the questionnaires was to learn from the village extension officers about their contact with and work towards farmers. Another aim was to learn about the agricultural practices in their villages and how they have changed in the past. Finally we wanted to compare the data from the questionnaires with the data received from field visits and interviews.

3.9 MIDTERM REVIEW

A midterm review[5] was held after four weeks of fieldwork in Babati. We presented our study methods and the study result so far. The participants gave us feedback and advices for the remaining part of the study.

3.10 WORKSHOP

A one-day workshop[6] on the concept of CA was conducted where farmers, district SMSs, village extension officers and NGO staff participated. The workshop contained

[4] See the questionnaire for village extension officers and a summary of the result from the questionnaire in Appendix IV and V
[5] See report from mid term review in Appendix II

discussions on three main areas with questions prepared by us. The questions were translated by the Babati CS-team and the workshop was mainly held by Mr. Mbise. We participated at the workshop only as observers.

3.11 PRESENTATION AT ICRAF, NAIROBI

The study was presented at a seminar at ICRAF in Nairobi, Kenya. After the seminar questions were asked and feedback and advices from the seminar participants were given.

3.12 IMPLEMENTATION AND DISCUSSION OF STUDY METHODS

This study was mainly built on interviews with various key-informants and stakeholders. Interviews were chosen as the main study-method because we were interested in different actors' experiences and perceptions of CA. Field visits was often done in connection with the interviews to get a better and increased understanding of the reality.

The reason for selecting three wards and not the whole district is that Babati District is large and the time for the case study was limited to only eight weeks.

Only 14 questionnaires was answered and returned. This amount may be too small to build any conclusions on, it can still used for comparing villages not visited with the villages visited.

3.13 DIFFICULTIES IN IMPLEMENTATION OF STUDY METHODS

Everyday out on the field and during interviews we met new challenges, many due to our own inexperience of conducting interview-based studies. Other challenges due to difficulties and misunderstandings related to the language. Working with interpreter turned out to be more difficult then we expected. Sometimes the questions asked by us during an interview were not fully understood and correct translated by the interpreter. Other times we misunderstood the answers given and sometimes the full answer was not translated. This limited us sometimes to go deeper into interesting issues. We also found it difficult to get farmers to talk freely without straight and sometimes leading questions.

We also noticed that our area of interest was very wide and this put us under time pressure during the interviews. Some interviews went on too long sometimes with other farmers waiting. The tools (farm sketch, timeline and seasonal calendar) for our interviews were only used during the first farmer interviews, sometimes with a good result but more often making the interview situation more complicated. In the end we therefore only used semi-structured interviews.

Working in collaboration with local agricultural experts had both advantages and disadvantages. The advantages with the collaboration were that they had very good knowledge about the area and it made contacts with political leaders, extension officers, NGOs and farmers much easier for us. They could also give us deeper

[6] See workshop schedule and prepared subjects and questions for discussion for the workshop in Appendix III

knowledge about the agriculture related issues in Babati District. Less positive was that during some interviews the presence of agricultural experts had an influence on the farmer and we sometimes felt that the farmer searched for good and right answers rather then sharing his or hers own thoughts and ideas.

RESULTS

This part of the study is divided into eight chapters. The first one (chapter number four) presents the study site; Babati District, with the purpose of contextualising the study. Chapter five describes the three wards that were selected for the study. Chapter six and seven, written by Fredrik Löfstrand, describes the agricultural history in the district prior to the introduction of CA, as well as the introduced CA practises. The eighth chapter, mainly written by Martin Löfstrand[7], presents various actors in the field of agriculture in the district. Chapter number nine, written by Martin Löfstrand describes and discusses the methods used in the diffusion of knowledge related to change of agricultural methods in Babati District, with a focus on CA related knowledge. Chapter number ten, written by Fredrik Löfstrand, describes the reasons behind farmers' adoption or refusal of CA, as well as the impacts CA has had in Babati District, at least among farmers met for the study. Chapter eleven, written by Fredrik Löfstrand describes the effect of different cultivation systems and how these affect soil fertility. Each one of chapters, six to eleven, ends with a summary and a discussion, followed by a part that presents gaps and challenges related to the discussed topic.

[7] M. Löfstrand report: *Conservation Agriculture in Babati District, Tanzania The Impacts of Conservation Agriculture for Small-scale farmers – how it is taught, learnt and adopted* is published at Stockholm Institute of Education, Department of Social and Cultural Studies in Education, 2005

4 STUDY SITE

In this chapter the study site will be described. The condition for agricultural production is highly affected by the environmental factors such as precipitation, temperature and soil type. Agricultural production is also affected by the structure of the community and therefore a brief description of the infrastructure in Babati District is found in this chapter as well.

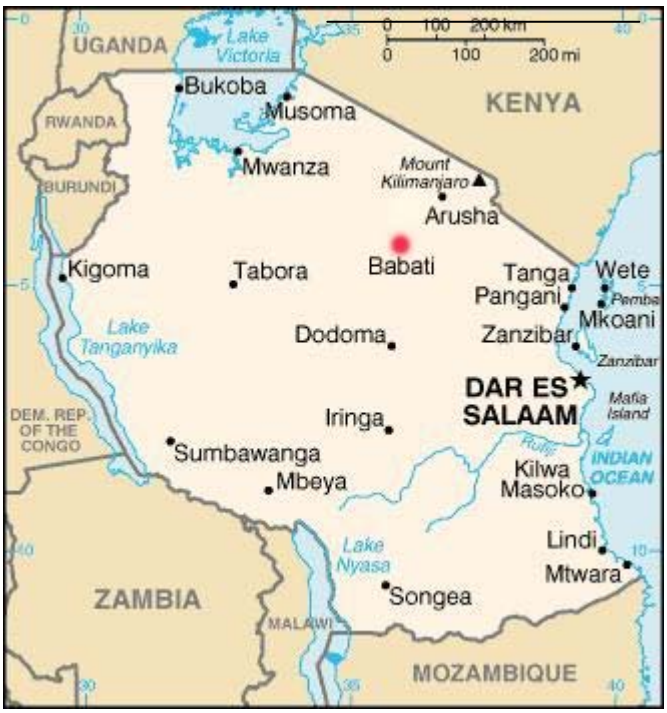


Figure 4.1 Map over Tanzania, Babati is marked as a red dot. (source: www.cia.gov, revised by F. Löfstrand)

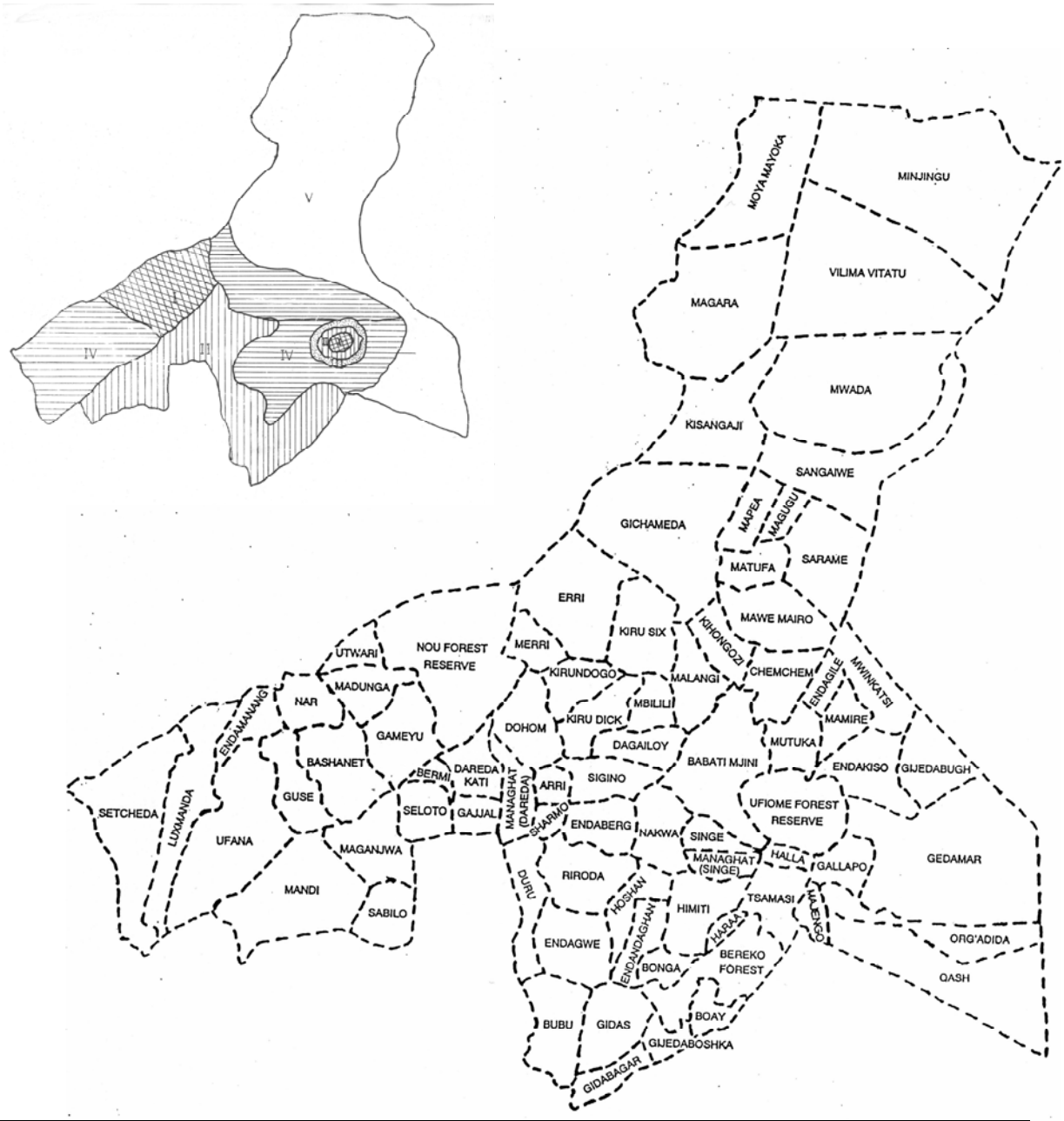
4.1 LOCATION AND GEOGRAPHICAL FEATURES

Babati District is situated in Northern Zone of Tanzania, see figure 4.1, and located between the latitude 3º and 4º south and the longitude 35º and 36º. The District is one of five districts in the Manyara Region. Babati District consists of four divisions, 21 wards and 82 villages. The biggest town in the district is Babati town with 31,000 citizens. Babati town is located 167 km southwest of Arusha and is the capital town of Manyara Region since 2002.

The total area of the district is 6 069 km^2. The Region is a part of the Great Rift Valley and the landscape is characterised by mountains, undulating hills and plains. There are five different agro-ecological zones (AEZ) in the district, fig. 4.2, and they vary from humid highlands (2150-2450 m a.s.l.) to semi-arid lowlands (950-1200 m a.s.l.) (Babati profile, 2002).

The rains are bimodal and the short rains begin in November and end in December/January period, while the long rains begin in February and end in May (Bishop-Sambrook, 2004). The short and the long rains are often connected (Bishop-Sambrook, 2004). Farmers met during the field study explained that they are not able to cultivate a crop during the short rains as they used to, due to a changed and more unreliable short rain period. The precipitation is related to the altitude and ranges from 1200 mm/year in the highlands down to 500 mm/year in the lowlands. In Babati town mean annual precipitation is 790 mm/year. During dry years like, for example, 1974/75 and 1981/82 the precipitation was as low as 390 mm/year, while in rainy years it can rain more than 1200mm/year (Department of Agriculture, Babati District)

The soils are mainly of volcanic origin and range from sand loam to clay alluvial soils. The content of organic material and availability of phosphorus is in general low in the district. (Jonsson, 1996)



No	Key	Agro ecological zone	Altitude (m a.s.l.)	Rainfall (mm)
I		Humid Highlands	2150-2450	1200
II		Sub Humid Highlands	1850-2150	1100-1200
III		Semi Humid Uplands	1500-1850	900-1100
IV		Semi Humid Arid Midlands	1200-1500	750-900
V		Semi Arid Lowlands	950-1200	500-750

Figure 4.2 The agro-ecological zones and the layout of villages in Babati District.
(source: Babati District council)

4.2 POPULATION

According to the Babati profile of 2002 Babati District has about 300,000 inhabitants and approximately 45 % of the population is under 15 years old. The major ethnic groups are Iraqw, Gorowa and Mbugwe and minor ethnic groups are Warange, Masai and Wanyaturu.

4.3 INFRASTRUCTURE

Babati District is connected to other districts in Tanzania with 4 important roads and this is the only transport mode connecting Babati District with the rest of the country. The total road network in Babati District is 1433 km; mainly earth mud roads (87 %). About 900 km of these roads are more or less un-passable during the rain season. (Babati profile, 2002)

Electricity is distributed through Tanesco that has 38 transformers in Babati District giving 4830 kVA, which carries a capacity for 10 000 persons. Today Tanesco reach 12 wards in the district including the Babati town council (consisting of 8 wards) with electric power and has a total of 2651 customers. According to the Area Manager of Tanesco in Babati District Tanesco plan and work to extend the electricity net to all wards in the district.

According to Babati profile of 2002 about 46-50% of the population or, 36 of 82 villages, is served with safe and clean water through 20 gravitational piped schemes, 2 surface pumped schemes and 5 deep well pumped schemes

In Babati District there are two hospitals, two Health centres and 25 dispensaries (Ljubinkovic, 2002).

Today above 95 % of the children in the district are attending school, but the district has an increasing problem of shortage of teachers. Another problem is adult illiteracy where Babati District is among the most underdeveloped districts in Tanzania.

Table 4:1 Education service in Babati District

Pre-schools (nursery schools)	44 (7,102 children)
Primary schools	146 (67,238 pupils)
Secondary schools	13

(Source: Babati profile, 2002)

There is one post office in Babati District situated in Babati town and one branch in Magugo. TTCLs 11 telecom-towers (placed in the ward of Riroda, Gallapo, Bonga, Gidas, Bashnet and Dareda (2) and in Babati town (4)) carry the capacity to cover all citizens in Babati District with the possibilities of telecommunication. TTCL has totally about 600 customers in Babati District but in the area Vodacom, Buzz and Celtel are also operating. One Internet café (The Rainbow Internet Café) is also to be found in Babati town.

4.4 AGRICULTURE FEATURES

The agricultural sector is undoubtedly the most important sector in the region and 95% of the inhabitants are depending entirely on agricultural production for their living (Babati profile, 2002). Generally in Tanzania about 80 % of the work force is employed in the agricultural sector (CIA, 2005).

The arable land is about 30% of the total land area but not all of this land is under cultivation. The main food crops are maize, paddy, sorghum and common beans while coffee, pigeon peas, sunflower and sugarcane are the most important cash crops (see Appendix VIII) (Babati profile, 2002). The main cropping pattern for the long rains is maize inter-cropped with pigeon peas or beans. During the period of the short rains single stands of beans are grown. Compared to other districts in Tanzania, Babati District is highly mechanised and about 60 % of the farmed land is tilled with tractors, 30 % are tilled by draught animals and 10% prepared by hand. (Bishop-Sambrook *et al.*, 2004)

Table 4:2 Land use in Babati District (Babati profile, 2002 and Ringo et al., 2002)

Land use	**Area**	**Percentage of land**
Arable land	180 000 ha (3 240 ha under irrigation)	30% (0,5%)
Livestock keeping	212 000 ha	35%
Forests	31 775 ha	5%
Parks and game reserves	142 500 ha	23%
Area for other uses	40 525	7%

Village land in Babati District is divided into different use categories such as farming-, communal-, grazing- and conserved land. Small-scale farmer households generally own about 2 ha of land and the village council allocates land to the farmers. Usually 0.8-1.2 ha (2-3 acres) per family is allocated for housing and farming. The allocation is normally to the husband and if he dies the ownership of the land is taken over by the spouse. A divorced or single woman can get a residential plot but no agricultural land. (Babati profile, 2002)

On land that is set aside as grazing land anyone can let his or her animal graze (Babati profile, 2002). The availability of agricultural land differs widely from different parts of Babati District. In some villages there are farmers that are not able to hire out land even though they would like to do so. In other areas young people are emigrating as an effect of land shortages and farmers are not able to increase their cultivated land area. The major cities attract young people that go to the cities to find other sources of income than farming. Higher level of education and better infrastructure makes this emigration easier.

5 THREE WARDS IN BABATI DISTRICT

5.1 MAMIRE WARD

Mamire is within the Babati Division in Babati District and consists of seven villages. In Mamire ward farmers from the villages of Mamire, Endakiso and Gijedabung were visited for the study. Individual interviews were conducted with six farmers. Interviews were also conducted with the leaders and village extension officer of the Mamire village and farmers involved in farmer groups.

5.1.1 Geographical features

Mamire ward is situated about 15 km northeast of Babati town and lies between Mount Kwaraa and the plains of Tarangire National park. The northern part of the ward is situated in the semi arid lowlands and the southern part in the semi-humid semi-arid midlands (AEZ V and IV), see maps in fig. 6:1. The landscape is rolling and are sloping 6-15% (Ringo et al., 2002) towards north and northeast and the altitude in the ward various from 1200 to 2200 m a.s.l.

The soils in the area are reddish sandy clay loams and sandy clays. The soil types are Luvic, Calcic and Haplic Xerosols, Orthic and Ferric Luvisols in the valleys the soils are deep dark cracking Perric and Chromic Vertisol. (Ringo et al., 2002)

5.1.2 Population

Mamire ward has a population of about 18300 persons and there are about 3550 households in the ward with the average size of 5 persons (Ringo et al., 2002).
According to the village leaders met young people are now emigrating from the ward to other areas due to lack of farming land.

5.1.3 Agriculture

The majority of the population is farmers in the ward and the average farm size is about 3 acres in Mamire village. Main crops grown are maize, pigeon peas and sunflower and the conventional farming system consists of tractor or oxen-drawn ploughs and planting with hand hoe.

Soil erosion, land degradation, deforestation and poor communication are some of the problems affecting the agriculture sector in the ward (Ringo et al., 2002).

5.2 GIDAS WARD

Gidas ward is within the Gorowa Division and consists of five villages. In Gidas farmers from Gijedaboshka and Boay village were interviewed. Individual interviews were conducted with five farmers, a group meeting with eight village leaders from the village of Gijedaboshka was held. Interviews were also conducted with the village extension officer, the owner of a recently started agricultural implement store and a farmer group.

5.2.1 Geographical features

Gidas ward is situated in the southern part of the Babati District on the boarder to Kondoa District. The ward is situated in the semi-humid uplands (AEZ III) see maps in fig. 6:1. The landscape is undulating with mountain foot slopes and valleys and are sloping 2-6 % (Ringo et al., 2002), the altitude in the ward various from 1400-1500 m a.s.l.

The soils in the area are yellowish and reddish sandy clays to clay with moderate organic content and subsoil acidity. The soil types are different Rhodic, Orthic and Xanthic Ferralsols. The soils in the piedmonts are reddish sandy clay loams and sandy clays, which include Luvic, Calcic and Haplic Xerasol and Orthic and Ferric Luvisol. (Ringo et al., 2002)

5.2.2 Population

Gidas ward has a population of 11300 persons and there are about 2200 households in the ward with the average size 5 persons, (Ringo et al., 2002). Due to shortage of land people are emigrating from the area and approximately 50 % move of to urban areas.

5.2.3 Agriculture

The majority of the population is farmers and the average farm size is 2-3 acres. Main crops grown are maize, sorghum and pigeon peas, the conventional farming system consists of tractor or oxen-drawn ploughs and planting with hand hoe, (Ringo et al., 2002).

Soil erosion, overgrazing, deforestation and low soil fertility are some of the problems affecting the agriculture sector in the ward.

5.3 MWADA WARD

Mwada ward is within the Mbugwe division in Babati District and consists of three villages. In Mwada ward six farmers from the village of Mwada were interviewed. A group meeting with the village leaders was conducted and some conversation with the village extension officer was done.

5.3.1 Geographical features

Mwada ward is situated in north east of Babati town. In the east the ward borders to the Tarangire national park and to the west the escarpment of the Great Rift Valley.
The ward is situated in the semi arid lowlands (AEZ V), see maps in fig. 6:1. The landscape is plain, sloping 0-2%, and with some smaller hills (Ringo et al., 2002).

In the water logging areas deep dark cracking clays like Pellic Vertisols dominates. In relatively none water logged areas soils are more reddish sandy clay loams and sandy clays of semi-arid regions. The soil types are Luvic, Calcic and Haplic Xerosols and Orthic and Ferric Luvisols. (Ringo et al., 2002)

5.3.2 Population

Mwada ward has a population of about 13000 persons and there are about 3000 households with the average size 4 persons.

5.3.3 Agriculture

A majority of the population is farmers and the average farm size is 2-3 acres. Main crops grown are cotton, sorghum, simsim, beans, sunflower, pigeon peas and maize, the conventional farming system consists of tractor or oxen-drawn ploughs and planting with hand hoe.

6 CHANGES IN THE AGRICULTURE SECTOR

Fredrik Löfstrand

6.1 AGRICULTURAL HISTORY

In this chapter the development of the agriculture and historical events affecting the agriculture in Babati District is described in short terms. The agricultural production has fluctuated during the past years and different projects has come and gone.

6.1.1 Settlement

In the mid18th century Iraqw people began to move from the southern Kondoa District to the area, that today is the Babati District. At this time they were divided into two groups, one of the groups settled in an area between Nou and Marang forest and formed the today's Iragw tribe. The other group settled in an area between Babati, Bonga and Bubu River and formed the Gorowa. As the Gorowa group came to Babati a group of Bantu agriculturist already lived there. Due to the Gorowa immigration some people moved to settle east of Lake Manyara and formed the Mbugwe while others moved south to the Kondoa District and formed the Rangi community. (Loiske, 1995)

Up to the 1950s Babati District was sparsely inhabited and just like today dominated by the two agro-pastoral people Iraqw and Gorowa (Hillbur, 1998). A few European estates were established in the area, which led to some immigration of labours to the area. A tsetse eradication programme was carried out in the end of the 50s and during this programme trees and bushes were cleared. After this clearance immigration to the area began. People settled and began cultivating the newly opened land.

6.1.2 Babati District - a grain basket

Babati District was seen as a grain basket up until the 80s and people remember how the farmers made maize pyramids outside their houses and on what today is the football field in Babati town (Kavishe, 2005) and according to village leaders in Mamire some farmers even left some crops in the fields during some years. According to Lindberg (1996) draughts and the oil crises in 1973 resulted in low yields and a crisis for the whole country. This shows that fluctuations in yields are something that has happened even during periods remembered as good.

During the 80s village storage's were built and in Babati town three big storages' were built (Kavishe, 2005). Several donors and NGOs tried to boost the agricultural production and the World Bank and South Korea supported the maize production with fertilisers. The mechanisation rate was high and there were about 500 tractors in the area. At the time there were not many people that considered erosion as a problem. (Kavishe, 2005)

6.1.3 Production reduction

During the 1980s poor harvests and total crop failures occurred frequently in Babati District due to regular crop water stress. The maize yields for example dropped by more than half. The water stress was caused by inadequate soil moisture even though the district has rather fertile soils and an average rainfall of 794 mm. The extension

service listed poor demand for costly fertilizer and improved seeds as bottlenecks. (Jonsson, 2000)

6.2 THE CA-INTRODUCTION

The work with introducing a more sustainable agriculture production was done years before the term Conservation Agriculture was known. Today many of the extension officers know about CA or *Kilimo Hifadhi* (as it is called in Swahili) and what practises it involves.

In the middle of the 80s a project started called Forest, Trees and People (FTP) that was supported by Sida, FAO and SLU. This project should strengthen tree planting and agro-forestry in some villages in Babati District.

In 1994/95 a survey was carried out by LAMP and this survey revealed that compacted soils where a major problem in the district and that this was limiting for the water infiltration and crop growth. A problem was also the sheet erosion that occurred between contour bounds due to the low infiltration capacity. This erosion caused low yields in the upper part of the field and higher yields in the lower part. (Jonsson, 2000)

Years of ploughing had led to a formation of a plough pan in many fields and this plough pan hindered both water and roots to penetrate deeper soil layers. To get rid of the plough pan deep tillage or sub-soiling with tine implements was tried in 1995/96 with a very positive result. The following season several demonstrations were done to both small-scale and commercial farmers. A problem that occurred was the low amount of tractors that had hydraulic systems that were powerful enough to pull the sub-soiler. The techniques that used draught animals were functioning well and were highly profitable and adoptable.

To overcome the problem of plough pans, farmers have to change tillage method and use something less compacting. The Magoye ripper were introduced at the same time as sub-soiling, 427 rippers were imported from Zambia and promoted by Tanganyika Farmers Association (TFA) Babati. Later a manufacturer in Moshi has done the production of the ripper. To spread the knowledge about ripping oxen training groups were formed and in those groups village extension officers and farmers were trained, see chapter 9.

From the survey held in 94/95 many recommendations were launched. Among those recommendations were application of farm yard manure (FYM), promotion of improved crop husbandry practices like improved seeds, inter-cropping and cover crops, alternatives to post harvest grazing, together called Dry Land Farming (DLF).

Another survey was done in 1998 and the outcome of that survey was that the uses of chemical inputs in the region were low and that Babati District could gain from an introduction of organic farming, as farmer could start using biological pesticides and green manure and improve the agriculture without any great expenses. On district level an interest was awaked and the work with initiating organic farming started, see chapter 11. (Msabha, 2005).

Today the CA-work has come to different stages in the district and among farmers. Efforts are now made to introduce the Magoye direct planter and weeder. Knowledge about cover crops is also spread and seeds of different cover crops have been given to some farmers.

7 CA PRACTISES IN BABATI DISTRICT

Fredrik Löfstrand

CA practises are not new and farmers use some of the farming techniques without much of considerations, but as the agriculture has become more intense farmers have abounded some of the practices. The intensification of agriculture and more dense population have made farmers abandon old practises for new ones, this changes have not always been successful. Some problems that have occurred are for example erosion, reduced yields, low soil fertility and compaction of soils.

Many of the CA practises that today are promoted in Babati District have been (re-) introduced by LAMP as DLF in mid-1990s.

7.1 AGROFORESTRY

During the 80s efforts was made to stop deforestation and land degradation, one tool used was agroforestry. Tree planting in and around fields and around homesteads should give the households a source of fuel wood, fodder, shade and timber. Trees along the field can also mark the boundary, reducing the risk of others claiming the right to the land. The trees can increase the amount of organic matter in the soil and the roots bind the soil and can thereby decrease soil erosion. Trees can also act as a nutrient pump, bringing nutrients from greater depths up to the surface.

Farmers plant trees like *Grevillia robusta*, *Sesbania sesban*, *Faidherbia albida* and *Casuarina equisetifolia* along contours and field borders. Sometimes they also plant different kinds of fruit trees. In Babati District, FTP established nurseries in four villages during 1988. The Chaggas that have moved in from Kilimanjaro area are also known for their agroforestry home gardens.

In many villages there are by-laws saying that villagers have to plant a certain amount of trees per year on his or her land.

7.2 CONTOUR BOUNDS

Babati District is a hilly area and many fields are situated on slopes. Erosion has therefore been a great problem in the area and contour bounds have been seen as an important start in improving the agriculture and conserving the soils. The first contour bounds occurred in the 1950s at the colonial farms and were also introduced by missioners, (Lyimo, 2005). In some areas villagers have tried to stop the erosion by putting trashes and trying to build contours, but these efforts has many times not been enough. In the early 90s LAMP began to form village teams consisting of extensions officers and farmers that were taught how to measure and build good contours, Fanya juu terraces. The teams went around and measured contours and after that it was up to the farmer to build the contour bound. Recommended is to plant trees or grasses on the contour bounds to stabilise them. It is also important to keep cattle out of the field as they easily destroy the contour bounds.

7.3 SUB-SOILING

Sub-soiling is done to break the plough pan and by doing so increase infiltration of water into the soil and allow plant roots to penetrate the deeper soil layers. Sub-soiling is often the entry-point to CA in the district as the plough-pan has to be broken before introducing reduced tillage methods. If farmers does not use minimum tillage the recommendation from the extensions service is to sub-soil the land every third year.

Sub-soiling in Babati District is done both with ox and tractor drawn implements. According to Mbise (2005) there are two tractor drawn implements to hire in the area and the cost of sub-soiling one acre with tractor is 17 000 TSH (Euros 12.3). In the past sub-soiling of about 500 acre/year has been subsidised by LAMP through the district with TSH 10 000/acre (Euros 7.24/acre) of the total cost, leaving farmers to pay the rest of TSH 7 000/acre (Euros 5.06/acre).

Sub-soiling can also be done with an implement that fits to a standard plough or ripper beam (Bwalya, 2003). The cost for using the animal drawn sub-soiler was TSH 8000/acre (Euros 5.79/acre) (year 2004).

The sub-soiling should be done when the soil is dry or slightly moisture (Bwalya, and Johanning, 1976) and in Babati District sub-soiling is usually done after harvest in September up till planting in December and January (Mbise, 2005).

Formation of plough pan is related to the soil type and sub-soiling is not recommended on all fields of Babati District. Black cracking clays or sandy soils are two soil types were sub-soiling are not recommended. Instead structure of the cracking clay soils should be improved by increased organic matter content and if sub-soiling is done on sandy soils a water deficiency can occur as the water level is lowered when macro pores are formed (Mbise, 2005).

7.4 RIPPING

To reduce the soil disturbance and keep and improve the soil structure ripping has been introduced to replace the conventional ploughing. The benefit with the ripper is that it only opens a narrow furrow every 75 cm and does not turn the soil nor incorporate crop residues into the soil. In conventional farming the land is ploughed one to three times to get rid of weeds and prepare the seedbed. To use the plough the farmer has to wait for the first rain to be able to start the activity. By using the ripper the farmer can begin to prepare the land earlier, when the soil is still dry. A negative effect is that the reduced tillage leads to higher impacts of weeds and to suppress the weeds herbicides or soil cover is needed.

Planting is done by dropping seeds in the furrow that the ripper creates. A planter attachment to the Magoye ripper is now being introduced in the region that will make direct planting possible. The ripper is also used for weeding between the rows and is then equipped with extended wings that cover the weeds with soil.

As the ripper does not turn the soil the draught power needed is also lower and only two oxen are needed instead of up to six as needed when ploughing with mould-board ploughs.

7.5 SOIL COVER

There are many ways to create a soil cover and protect the soil from heavy rains, heat and to suppress weeds. A soil cover can be established with crop residues, cover crops, mulch and use of intercropping. Intercropping is very common in Babati District while the uses of cover crops are more recently introduced.

Cultivation of cotton could not be combined with any type of soil cover or intercropping, as the cotton has to be clean to give a good price. Farmers were therefore recommended to avoid these practises in cotton fields.

7.5.1 Intercropping

The most common cropping system in Babati District is intercropping, which is practised by about 60% of the farmers (Babati profile, 2002). Pigeon peas is often intercropped with maize and gives a cover during a long time period, see figure, it is also a nitrogen fixating crop and can therefore improve the soil fertility. Maize and pigeon peas are planted at the same time either in separate rows or in the same row. The pigeon peas are also preventing post-harvest grazing, as it is a crop that stays long in the field. The introduction of pigeon pea intercropping came spontaneously as there was a good market for it. Most of the pigeon peas produced are exported to India.

Common bean (*Phaseolus vulgaris*) is also used in intercropping both with maize and with sunflowers. When sunflowers and beans are intercropped sunflowers are planted with eight rows of beans in-between.

On farmer met during this study planted sun hemp (*Crotolaria juncea*) around the fields. This was done because the family had seen benefits with reduced attacks from the stalkborer as the insect attacked the sun hemp instead of the maize.

7.5.2 Crop residues

After harvest farmers in Babati District are now told to leave the crop residues in the field to establish a soil cover to protect the soil from the sun and heavy rains. The soil cover is also said to preserve moisture and recycle nutrients. Usually the crop residues are used as fodder for livestock and not left in the fields. The practise of leaving crop residues in the field is becoming more common in the area, but there is still a demand for the residues as fodder.

On fields where the residues are left livestock that enter the fields is a remaining problem, making it difficult to keep the soil covered. Many farmers are also still ploughing their fields, sometimes due to low availability of rippers. This results in a poor soil cover after land preparation leaving the soil bare when the rain comes. The incorporation of the crop residues can also lead to an immobilisation of nitrogen when the stovers are decomposing

Farmers usually have to clear rows or parts of the field before tillage with the ripper as the crop residues otherwise clog the ripper, some farmers slash the residues with a panga (machete) into smaller pieces to overcome the problem. A knife roller has been tried in the district but the result was not satisfying as it only pressed down the residues and did not chop them.

Fig. 7.1 Direct planter built by the farmer Mr. Kitutu in Mamire ward.

Fig. 7.2 Eroded river bank in Mamire ward.

Fig. 7.3 Soil cover with pigeon peas and maize residues.

Fig. 7.4 Field with the cover crop *Lablab purpureus*, after maize harvest

Fig.7.5 Field with *Faidherbia albida*, *Lablab purpureus* and maize residues.

Fig. 7.6 Maize and the cover crop *Mucuna pruriens*.

Fig.7.7 Zero-grazing stables for cattle at IATC.

Fig. 7.8 Contour bound established with *Grevillia robusta* and Elephant grass (*Pennisetum purpureum*)

7.5.3 Cover crops

The use of cover crops has many advantages for example it can give a soil cover, green manure and/or give the farmer a more secure yield, as two crops are cultivated. After introduction of reduced tillage the mechanical weeding is reduced and the farmer has to suppress the weeds in other ways, cover crops are one way. Some cover crops are used traditionally for example pumpkin, calabash and watermelon, the effectiveness as cover of these crops can be discussed. Today lablab (*Lablab purpureus* earlier called *Dolichos lablab*) and velvet beans (*Mucuna pruriens*) are promoted in the Babati District and demonstration plots are established to show the effect of these cover crops. The use of cover crops is the next step for many farmers to take in their CA practise.

7.5.4 Mulch

Mulching in the meaning of bringing plant material into the field is not widely spread in the area. This practise was only seen in a banana field.

7.6 ZERO-GRAZING

Livestock in the area normally graze on farmlands after harvest which make establishment of soil cover consisting of crop residues and mulch hard. Common is also that livestock grazing in fields destroy contour bounds. The grazing practise disagrees with the CA practise and livestock keepers have to find other ways of feeding their animals. Zero-grazing is one way of reducing the number of livestock grazing freely in the fields. Zero-grazing means that the livestock are kept in a stable or are tied up. As the animals are fed this practise leads to a higher demand for fodder crops and farmers therefore have to cultivate grasses and trees for this purpose. This is often done along contour bounds and field borders.

7.7 RIDGING

Ridging is a technique that only is used to a minor extent in Babati District. Ridging is mainly used for some root crops like for example sweet potatoes and cassava. The ridges are mainly done with hand hoes.

7.8 JAB PLANTER

Jab planter demonstrations were held in 2003 but as Babati District have a high number of tractors and draught animals, farmers consider the use of jab planters being a step backwards. This has made the low or non-existing adoption of the jab planter.

7.9 SUMMARY AND DISCUSSION OF CA PRACTISES

Population growth, introduction and development of new technologies together with higher living standards resulted in a demand for higher incomes and have driven the agriculture development in Babati District. It has resulted in, for example adoption of tractors and oxen, mould-board and disc ploughs, intercropping of pigeon peas and that more and more land have been taken into cultivation. This development has led to a sometime unsustainable agriculture and depleting and erosion of soils. Tractors and oxen made it possible for farmers to increase their farmlands and when a decrease of yields per acre occurred due to these practices it did not matter as long as farmers got enough. The higher demand for land and food had somewhat changed the perspective and the yields had to increase per acre.

Historically agriculture developed as different tribes met and shared knowledge. In the resent years many of the new technologies and practises have been introduced from abroad. In the middle of the 90s the change towards CA came to Babati District as LAMP together with the district council introduced DLF. Efforts were done to restore the soils and introduce a more sustainable use of the soils and at the same time increase the production that had declined during the past years. The new techniques included breaking of the plough pan by sub-soiling, use of the ripper instead of the conventional ploughs, establishment of contour bounds and introduction of soil cover and cover crops. Many farmers were interested in the new practises and said that they have seen good outcomes from neighbours or demonstration plots where the new practises were used. Even though the farmers had seen the benefits they did not change practise on their own fields due to different reasons.

7.10 GAPS AND CHALLENGES IN CA RELATED PRACTISES

Farmers have during a long time been told to plough their fields and create a good seedbed without any weeds. As the Magoye ripper and reduced tillage were introduced farmers had to relearn, as the new practise does not kill the weeds. The weeds were a problem farmers had to fight with and only a few could afford herbicides. Many farmers met during the study also hesitated and did not want to use chemicals on their fields as they thought they were bad for the nature. To fight the weeds farmers were told to establish a soil cover by planting cover crops or leaving crop residues in the field. One problem was that this soil cover made the use of the

ripper more difficult as the plant material tended to clog the ripper. A knife-roller had been tried in the district for killing and chopping the plant material. The result had not been satisfying as the knife roller had been to light and had to be filled with water to do a proper job.

7.10.1 Challenges with cover crops

Problems with insects had occurred for the farmers that were using the newly introduced lablab as a cover crop. There were pesticides available but it was often hard for the farmer to get the pesticides and sprayer in time and also to afford the new expense that it brought. Another problem were that the farmers used low concentrations in an attempt to save money and the pest problem remained. CA-experts at Selian Agriculture Research Institute (SARI), Arusha, expressed that the insects did not have an impact on the soil cover as the insects attacked the seeds and not the green plant. For the farmer the insects were somehow a problem as the production and income from the lablab decreased if insects attacked it. For the velvet bean the market was poor and some varieties were even poisonous. Even though it gave a good soil cover, adoption of velvet beans will probably remain weak as long as the problems with the market and poison remains.

Many farmers in Babati District were agro-pastoralists and the number of livestock in the area was high. It can be difficult to combine a high number of livestock and CA practices. The traditional post-harvest grazing was expressed as being a contradictory interest that was not compatible with soil cover and contour bounds. Livestock keepers had low or no understanding for this waist of fodder.

8 AGRICULTURAL RELATED PROGRAMS AND NGOS

Martin Löfstrand

One aim with the study was to describe the actors and their work done in Babati District of spreading knowledge about CA and motivate and support local farmers to introduce CA in their own farming practices. Below follows a presentation of the main NGOs, institutions and organisations in Babati District active in the field of CA followed by a summarize of all NGOs, programs and organisations that is or has been active in the agricultural sector.

8.1 FARMAFRICA

FARMAfrica (FA) is a British NGO established in Babati District in 1994, FA were registered in Kenya year 1985 and is today operating in six countries: Kenya, Uganda, Ethiopia, South Africa, Sudan and Tanzania. Their aim is to eliminate poverty through assisting small-scale farmers to use their own resources to improve their livelihood.

The ongoing activities under FARMAfrica in Babati District are the following:

- Babati Rural Development Project
- Babati Agricultural & Environmental Education Project
- Nou Joint Forest Management Project

8.1.1 Babati Rural Development Project

Babati Rural Development Project (BRDP) is aimed to improve the agricultural productivity and sustainable land-use in the district. The main activities under BRDP that concern agriculture issues are the dairy goat improvement where FA is supporting Toggenburg Breeders' Association (TOBRA) and farmers to spread crossbred dairy goats, the community animal health project trains and monitors Community-based Animal Health workers and have so far trained 155 farmers in 76 villages and the Farmer Research Groups were farmers are given an opportunity to practise and participate in research concerning agriculture. BRDP is funded by CORDAID and EU, giving a total of Euros 1.444.073 from 2000 to 2005. (Pound et al., 2005)

8.1.2 Babati Agricultural & Environmental Education Project

Babati Agricultural & Environmental Education Project (BAEEP) is a pilot project that started with 13 schools in Babati District in 2003. The aim with the project is to improve the agricultural and environmental education in primary schools. During the first year the main activity was training of teachers in participatory methods and strengthening the capacity of the school-committees. BAEEP is funded by a number of various British trust funds giving a total of UK£175.988 (Euros 257.067). (Pound et al., 2005)

8.1.3 Nou Joint Forest Management Project

Nou Forest has been a forest reserve since 1933 and FA is involved in establishing a good management of this reserve. Nou Joint Forest Management Project (NJFMP) is funded by EU, the Humla Fund and the JJ and Equator Charitable Trusts and has a planned budget for 2000 to 2005 on total of UK£1.08 million (Euros 1.577.563). (Pound et al., 2005)

8.2 FRIENDS IN DEVELOPMENT TRUST FUND

Friends in development trust fund (FIDE) is a local NGO that was established in 1991 (registered 1992) by people from Babati District. FIDEs vision is a poverty free society where human rights are observed, everyone has access to the basic needs in life and resources are enjoyed by all and used in a sustainable way. FIDE is active in a wide range of areas from health and education to agriculture and renewable energy. These activities are conducted with resources from many different donors but the main donor is Helfen durch Teilen, Austria. Since the start FIDE has invested TSH 77.664.500 (Euros 56.195) (up till year 2001) in development projects (Ljubinkovic, 2002)

Ongoing agricultural related activities under FIDE are:

- Agroforestry
- Soil and water conservation
- Small-scale farming
- Training activities on livestock and crop production

8.3 LAND MANAGEMENT PROGRAMME

LAMP is a programme that started in Babati District in year 1989/90 the programme is funded by Sida and is a joint initiative between the Tanzanian and Swedish governments. LAMP aimed to be a programme for funding rather than a conventional development project where the donor is directly involved in implementation. Instead LAMP is to support development projects planned and implemented by the citizens and their organisations in Babati District.

8.3.1 History of LAMP

From the year of 1981 Sida was supporting the Community Forestry Programme (CFP) that included agroforestry in Babati District. In 1987 started FTP that was an applied research project focussing on the development of tree growing techniques for the CFP. Main activities under FTP were: finding low-cost techniques of raising nursery stock by using local resources and development of the village forestry concept. During this time the Tanzanian authorities raised their concern for the increasing land degradation in areas of good agricultural potential in Babati District. A study was done as a preparation for a new project on environmental conservation to secure increased production through improved land use, land management and soil and water conservation. The report[8] from the study summarized eight environmental problems all caused by man through exploration of natural resources three of them was:

- Decreasing agricultural productivity due to widespread soil and gully erosion
- Overgrazing caused by decreasing pasture arising from constant invasion of pasture areas by cultivators
- Shortage of fuel wood, timber and poles caused partly by inadequate afforestation programmes in the District (Ericsson et al, 1990)

[8] Babati LAMP Project – Babati Land Management Pilot Project for Environmental Conservation 1988/89-1991/92, distributed in June 1988

After the study FTPs infrastructure and activities were handed over to LAMP and LAMP started as a programme with the objective to Increase Agricultural Production through sustainable Use of Natural Resources with the aim of eradicating poverty.

8.3.2 Activities under LAMP

LAMP activities in Babati District are divided in four components:

- Land Security
- Community Empowerment
- Farmers Extension Services
- District and Village Capacity Building

LAMP has had many and successful activities related to forestry and LAMP has also introduced DLF in Babati District.

8.4 TANGANYIKA FARMING ASSOCIATION

TFA is a company established in Tanzania 1951.TFA has one agricultural implement store in Babati town and is the main supplier of agricultural implement in Babati District both for local farmers and for small implement shops in the surroundings of Babati town. TFA were involved as the distributor in LAMPs introduction of the Magoye ripper in 1995.

8.5 INTEGRATED AGRICULTURE TRAINING CENTER

The Integrated Agriculture Training Centre (IATC) started in 1993 as a fishpond-training centre and was funded by a German organisation called Bread for the World. The centre started with the aim to reduce poverty for small-scale farmers. In 1995 they also established agro-forestry demonstrations and today they cover a wide arrange of subjects that are all close connected to environmental conservation such as organic agriculture, sustainable energy resources, livestock keeping etc.

The centre works in close cooperation with both district and village extension officers, as well as local NGOs. The centre is continuously working together with LAMP, FIDE and FARMAfrica. Extension officers and farmer groups as well as individual farmers are trained at the centre.

Today the institution is mainly self-supported through incomes from training fees, and through selling of crops, vegetables, fruits and livestock. It also gets support from the Evangelical Lutheran Church in Tanzania. The centres yearly turnover is approximately TSH 100 Million (Euros 72356). (Sokoitan, 2005)

8.6 SUMMARY OF PROGRAMS AND NGOS AND THEIR ACTIVITY

In Babati District there are several programs and activities run by different NGOs and institutions. The organizations met have in general been active in many different areas building schools and roads one day and introducing sustainable energy and educate people about HIV/AIDS the next they. The activities related to agriculture are often done in cooperation with the district and village extension officers. Most of the activities that introduces CA related technologies are held and/or financed by LAMP

and FA. In the table below (table 10:1) programs, institutions and NGO that is and has been active in the agricultural sector in Babati District are shortly presented.

Table 8:1 NGOs and institutions that are or have been active in the agricultural sector

	Institution/Organisation/Program	**Description of activities**	**Time in Babati District**
1	FARMAfrica	Various agricultural related activities. Big dairy goat project that motivates zero-grazing	Active since 1994
2	Friends in Development Trust (FIDE)	Various sustainable development activities, some agricultural related	Active since 1991
3	Forest Trees and People (FTP)	Forestry and Agroforestry projects, tree nurseries Building of contour bounds.	1987-1989
4	Heifer Project Tanzania (HPT)	Dairy cow breeding project	Active
5	Integrated Agriculture Training Center (IATC)	Training of farmers and extensions in agriculture, livestock, agroforestry and fish ponds	Active since 1993
6	Land Management Programme (LAMP)	Dry land farming (sub-soiling, ripping, agroforestry) Organic farming (soil cover pest management, FYM) etc.	Active since 1990
7	National Agricultural and Livestock Extension Rehabilitation Project (NALEP)	Improved agricultural and livestock extension through Training and Visit approach	1989 – 1996
8	National Agricultural Extension Project (NAEP II)	Improved agricultural and livestock extension towards a participatory approach	1996 – 2003
9	ORIDOY – Cotton cooperation	Cotton production	Active
10	Promption of Integrated Development and Relief Services (PIDERS)	Farming as a business	Active since 2005
11	SACCOS	Micro finance groups	Active
12	Selian agricultural Research Institute (SARI)	On farm demonstrations, introduces new banana varieties	Active
13	Tanganyika Farmers Association (TFA)	Agriculture implement supplier	Active

9 DIFFUSION OF AGRICULTURE KNOWLEDGE

Martin Löfstrand

In the previous chapter the programs, organisations and institutions active in the agricultural sector were presented. One aim with the study was also to give answers on how CA-related knowledge were produced and transferred and what approaches and methods that has been used in this process. This chapter aims at describing the diffusion process of agricultural knowledge and CA related knowledge, as well as the methods used in the diffusion process.

Most farmers in Babati District are practicing what they were taught by their parents. Knowledge about other agricultural practices is mainly spread through the agricultural extension service and various farmer groups. LAMP is a strong supporter of the extension service and the agricultural related NGOs are all using the already existing resources of village extension officers in their agricultural related activities. It is therefore a need to understand the function of the extension service to understand the diffusion processes.

9.1 EXTENSION SERVICE

Agricultural extension aims to improve the productivity of agricultural systems, raising the incomes of small-scale farmer families and improving the quality of life of rural farm household extension service has a long history and has gone through a lot of changes in Tanzania and in Babati District.

9.1.1 History

Extension in Tanzania and in Babati District started during the colonial era. The extension was then aimed at boosting agricultural production and had a strong focus on cash crops (Tanzania - Ministry of Agriculture and Food, 2000). In 1972 the government introduced a decentralization policy which transferred the administration of extension services from the Ministry of Agriculture to the Prime ministers office. Extension officers were disappointed with the new system because it led to a situation were extension where no longer a scientific discipline that could only be done by qualified personnel. The disappointment and frustration among the extension officers led to a low working moral.

Ten years later the agricultural sector including the extension service were centralized, but remained ineffective. This ineffectiveness was leading forward to a project called the National Agricultural and Livestock Extension Rehabilitation Project (NALERP). NALERP started in 1989 with the aim of strengthening the extension service in whole Tanzania. NALERP implemented Training and Visit (T&V) extension approach which resulted in increased agricultural output and higher number of farmers in contact with extension staff (Tanzania - Ministry of Agriculture and Food, 2000). Problems found with NALERP and the T&V approach, which is a top-down methodology, were that the extension was not demand driven and that issues of relevance, cost effectiveness, ownership and sustainability were not given any thoughts (Tanzania - Ministry of Agriculture and Food, 2000). NALERP went on up to 1996 when a second phase of the project started the National Agricultural

Extension Project (NAEP-II). According to the Main Report prepared for the Agricultural Extension Reform in Tanzania (Tanzania - Ministry of Agriculture and Food, 2000) NAEP-II improved the relevance, cost effectiveness and the sustainability of the extension service through using participatory methods together with the essential elements of T&V that were already in use.

According to Ms. Msofe (2005) farmer group methodologies were introduced and cooperation between the extension service and research stations, NGOs and other organisations began to improve during the time of the two projects.

9.1.2 Extension service in Babati District

In 2003 extension service was again decentralised and today the Agricultural department at district level is found under the Ministry of Agriculture. The extension service is financed by the public sector but is often highly dependent on external funding. The district council in Babati has during a longer period received funds by Sida.

Babati District is divided in ten agricultural divisions in each there is one division extension officer. The administrative divisions are divided in wards, in each ward there is a team of village extension officers forming a Ward Extension team together with livestock, forest and community development staff. In most of Babati Districts 82 villages there is a village extension officer.

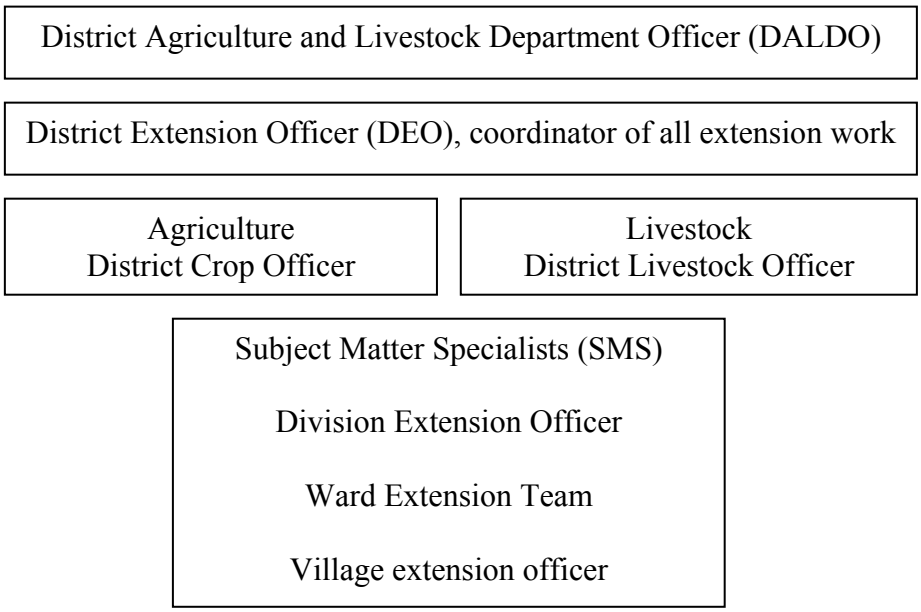


Figure 9:1 Structure of Babati District Agricultural and Livestock Department.

9.2 DECISION MAKING

According to Ms. Msofe (2005) the extension service in Tanzania has been more supply driven than demand driven. Opportunity and Obstacles for Development (O&OD) is a recently introduced system in Tanzania that is ongoing in Babati District that seems to have the strengths and possibility to change this. Decisions on what activities that will be budgeted and carried out will be made on a proposed

development plan that is done by the villages alone. Also the activities done by NGOs and other actors are to follow these plans.

9.2.1 The O&OD process

- **Sub village level**: Villagers state their problems and propose activities
- **Village level:** The village counsel with about 25 members goes through the plan and come up with a proposal Then the village assembly (all villagers older then 18) does the final decision of the plan.
- **Ward level:** Ward development committee that consists of the chairmen of the villages in the ward creates a ward development plan
- **District level:** The development plans reaches the DPO at the district; the DPO goes through the plans and send different parts due to area of subject to different district officers. The district management team goes through the plan and set up the budget, budget that is to be covered by different contributors; NGOs, village own contribution and district contribution. Before the final decision, made by the full counsellor/general assembly, the budget goes through a number of instances; function committee team, finance committee, regional secretary.

These O&OD village plans are made for a three-year period, but a budget is made each year. This year 50% of the funds provided for development projects and activities went direct to the villages. The provided fund for agriculture goes mainly to salaries for extensions, fuel, stations and training equipment.

9.3 FORMAL TRAINING ACTIVITIES

9.3.1 Farmer groups

In Babati District as already mentioned NGOs and donor funded programs are often working through the existing extension service. The initiative of extension activities seen in this study often comes from the NGOs and their working methods are often different kind of participatory approaches. (Abdallah, 2005) In the time for this study most of the support given farmers was done through farmer groups. Various farmer groups and special women groups existed in the, for the study, visited villages. Farmer groups that we met during the field study functioned in the same manner. First information about the group was given at a village meeting. Key-farmers, both men and women, from different sub-villages were selected sometimes after signing up as interested in participating. These key farmers were then trained by district and/or village extension officers in the subject. After training they were to practice what they learnt in their own field and sometimes also acted as trainers of other farmers (farmer to farmer training). The fields of the key-farmers were then also to work as demonstration fields for the rest of the villages.

9.3.2 Farmer Field School

Farmer Field Schools (FFS) had recently been introduced in Babati District by FA and LAMP but also on the initiative of village extension officer. The FFS follows the concept of learning by doing. A group of farmers met on a general basis to discuss and practice farming together. The extension officer sometimes joined the group but then more as a facilitator then a teacher and mainly if the group carried a burning

question. The FFS group participants that we met during the field study were positive to the FFS approach and expressed that it had helped them to improve their farming. Their FFS contained the activities of a normal farming year; the group used a plot they had hired in the area. Among the subject they had discussed and practised were:

- Crop rotation
- Sub-soiling
- Building of contour bounds
- Organic herbicides instead of chemical
- Good/bad pest
- Approaches to store sunflower

9.3.3 Farmer research groups

FA had introduced Farmer research groups or Farmers Participatory Research in Babati District in year 2000 with the aim of improving agriculture technologies through farmers' participatory research. Initially nine villages were selected and a total number of eleven groups were started, today the number of groups had grown to 70 spread in the district. The FRGs had mainly tested different seed varieties to find the most suitable variety for the area, IPM, composting and soil and water conservation had also been subjects for research in the groups.

The participants in the FA supported groups had been obliged to share their knowledge to about five other farmers in that way the knowledge is to spread outside of the group. Together with the groups three input shops had started by the participants that provide the village with seed, they also planned to distribute other agriculture implements in the future.

9.3.4 Organic farming groups

Organic Farming was one of the more recently started activities under LAMP extension services. In 2001 five farmers were selected in five villages (Halla, Endakiso, Mawemairo, Kiro Six and Duru) and together with the five village extension officers they had been trained on basic principles of organic farming. Every farmer had established a demonstrations plot where the following activities were demonstrated:

- Use of cultural control in controlling field insects/pests
- Use of biological control in controlling field insects and storage pests
- Use of natural fertilizers in maintaining soil fertility

Reduced/zero tillage, inter-cropping and soil cover are the CA-related activities that the extension staff and farmers are trained in through the organic farming groups.

In time for the study the activity had spread to another six villages (Kwaraa, Matufa, Erri, Kiru Dick, Dareda Kati, and Mamire) and a total number of 160 farmers were involved in organic farming groups. (Msaba, 2005)

9.3.5 Oxen training groups

Animal traction has been important in Babati District for a long time and therefore lot of efforts have been made through LAMP since 1997 to train village extension officers and farmers in the district in how to train and use oxen.

In 1996 mechanisation officers were trained in all of the four LAMP districts. The year after LAMP started to train the village extension officers in groups of

twelve. Totally 89 extension officers were trained in Babati District. After the training of village extension officers, 36 key-farmers from four different wards were selected and trained. In time for the study 25 groups were formed and approximately 250 farmers had been trained and another 36 farmers had also been trained in constructing ox-carts.

The training consists of:

- How to select animals
- Animals' health and good treatment of animals
- How to train animal
- Construct different yokes for the different use and what timber to choose
- Using the Animal for:
    - Mull-board ploughing
    - Ripping (Magoye ripper)
    - Sub-soiling (Magoye ripper)
    - Planting (Magoye ripper with planting implement)
    - Weeding (Magoye ripper with wings)
    - Transport with ox-cart

The training also consists of awareness making of the problem concerning the use of the mull-board plough due to plough pan. The benefits in using the ripper and how to continue a good agricultural practice after introduction of sub-soiler and ripper through leguminous crops and soil cover. In time for the study the training activity was also done through farmer groups supported by FA. For the different subjects different SMSs are involved, for example the district forest officers were involved in training village extension officers and farmers on how to choose good (light and strong) timber for yokes and the livestock department were involved in training on animal health. (Mbise, 2005)

9.3.6 Dairy goat project

The Dairy Goat Project was already as mentioned one component under FAs BRDP. The work started in 4 villages in Dareda ward in 1994, in 1998 the work expanded to the whole district. In the year 2000 the work was taken over by TOBRA (association of goat producers) and was in time for the study only supported by FA.

One CA-related practice in the project was the use of zero-grazing and the farmers were trained in building of zero-grazing stables for goats. Farmers were also encouraged to plant fodder trees along contours for purpose of soil conservation and to make good use of the manure from the goats.

Table 9:1. A Summarize of existing farmer groups in Babati District 2005 met during the study.

Farmer group	Main subject	Supported by
Farmer Field School	Improved agriculture	FARMAfrica LAMP
Farmer research group	Crop production	FARMAfrica
Oxen training group	Training of oxen Dry land farming	LAMP FARMAfrica
Stove group for women	Improved clay stoves	LAMP
Dairy goat program	Cross breed goats Zero-grazing stables	FARMAfrica FIDE
IPM	Integrated pest management	LAMP
Organic farming	Organic pest management	LAMP

9.3.7 Training of Tractor drivers

Training of tractor drivers was something done under FTP after seeing how the fields were ploughed in the direction of the slopes going up and down creating perfect circumstances for the water to come down and fast ran off the fields.

More recently; eighteen tractor owners have been trained through LAMP since 1996. The training has consisted of proper ploughing, but also awareness making of the problem concerning the use of the plough due to creation of plough pan. The tractor drivers have also been trained on how to construct contour bounds with disc-ploughs and cultivators.

9.3.8 Farmers study tours and demonstrations

Farmer study tours are often used as a part of the training and were expressed by extensions and farmer that we met as being one of the most effective ways in motivating farmers to change practice. According to the farmers that we met it was important that the field visits and study tours demonstrated real practices that they could relate their own agricultural practices to, therefore the concept of demonstration plots in every sub-village were also expressed as very good. The so called key-farmers, they that had been trained in farmer groups, were to use their farms as demonstration plots and also act as supervisors giving advice to their neighbours.

CA-related activities that we found on demonstration plots in the district were:

- Construction of contour bounds
- Agro-forestry
- Sub-soiling
- Ripping
- Soil cover; various cover crops as well as leaving of crop-residues

There were two training centres in Babati District. IATC and the Waang'waray, the two centres were located in two different agro-ecological zones and demonstrates farming in two very different climates. The training centres were used for training of both village extension officers and farmer groups. Waang'waray was established under LAMP and has a strong focus on agro-forestry and tree nurseries. IATC was

established under the Evangelical Lutheran Church in Tanzania, both were established in 1993.

9.3.9 Leaflets and other written materials

Both LAMP and FA have produced leaflets, extension manuals and other material for spreading of information and knowledge about different agriculture related subjects. Some of the subjects are storage of crops, soil cover, composting, top dressing, compost manure and animal draft implements. Most of the material were written in Swahili and distributed and used during training of farmer groups.

9.3.10 Agriculture in school

Generally the primary schools in Babati District had a field were the pupils were to do some farming. The fields have up to the time for the study mainly worked as an income source for the school and the work on the fields had not contributed to the pupils' agricultural knowledge. Even though the bigger part of the pupils according to Masalogo at FA would have to earn their living as farmers after finishing primary school they received an insignificant knowledge in agriculture through primary school. In the time for the study agriculture was one of seventeen so called "study ya kazi" (home economics) subjects of whom the teacher could choose three subjects to teach from. Often more popular and fun subjects as sports and cooking were chosen. Another reason why teachers were not choosing agriculture was their poor knowledge in the subject. (Masalogo, 2005)

Previously (1994-2002) FA had worked with implementing the activities they dealt with in their village-based projects also into the schools. For example draught power, tree nurseries and tree planting. As already mentioned FA started BAEEP in 2002 as a pilot project in 13 schools in Babati District with the aim of improving the quality of and the methods used in teaching agriculture and environmental issues. In the first year of the project the main activity was training of teachers in participatory methods and strengthening the capacity of the school-committees.

9.4 FARMER'S PERCEPTION OF THE METHODS USED

Farmers that we met during the study and that were personally involved in farmer groups were in general very positive to the groups. Both farmers and village extension offices expressed a strengthened trust in experts' advice and for the extension service, partly due to the changed extension methods. One farmer expressed that there had been a good communication and collaboration between him and the extension service. Another farmer explained that in the past the village extension officer had walked around talking or shouting at very big meetings and no one or a very few farmers had listened. One farmer that were not involved in a group had very little or no knowledge about key-farmers, farmer groups and CA and therefore also very little to say about the methods used.

Farmers' perceptions were also very good on demonstration plots and field visits. They expressed that it would be good if demonstrations were used in a higher extend in training and motivation of farmers.

9.5 THE ROLE OF OTHER ACTORS

Organisations, institutions, programs agricultural experts and extensions were mentioned as important actors in the process of CA related knowledge production and transfer in Babati District. Other important actors were the key-farmers trained in the groups. How big the influence was from the key-farmer on other farmers was highly dependent on the relationship between the key-farmer and the neighbouring farmers. During the study farmers in one village expressed that there were no conversations about agriculture between people, except within the family and in other villages the contrary was expressed; that it was very easy to discuss agriculture. The market were also one actor that had an impact on the farmer, not in producing knowledge or transferring it but bringing motivation for applying it.

9.6 SUMMARY AND DISCUSSION OF CA DIFFUSION

Diffusion of agriculture knowledge and knowledge about CA were ongoing in Babati District, with many actors involved. Farmers that we met during the study were in general very interested and open to new ideas that could improve their practices and increase their yields. We met some innovative farmers and farmers who really searched for new ideas and knowledge on how they could improve their farming.

Generally, the methods used for diffusion were through various farmer groups but also through farmer field days and village meetings. Different actors, especially the NGOs, stated that they were using participatory methods and approaches in their activities such as farmer field schools and farmer research groups. In these groups, farmers were often really involved in the development and improvement of their agricultural practices. But during field visits we also met farmers not knowing what had been done on their fields by specialists and extension staff. Many extension officers were using words such as bring, deliver, sending messages, disseminate and educate improved agriculture, new research or innovations, when describing their reasons for going to farmers (Questionnaire).

9.6.1 Training the next generation of farmers

During the study it was expressed that most of the young people in Babati will work as farmers after primary school, but hardly anyone received agricultural education. The knowledge they get about farming came from the childhood while they worked in the family's field. In school, pupils were often practising agriculture on fields belonging to the school, but this was seldom related to any education. Therefore the recently started BAEEP, a project that aimed to improve agricultural education in primary school, were very interesting. If children could be taught about different agricultural practices in school they would get a better foundation for their adulthood.

9.6.2 Believe only what you see

Farmers' motivation to change practice seemed to come from visible impacts as increased yields or better quality of crops. According to Mr Liymo (2005), farmers needed to be highly convinced before they applied the knowledge and words seemed not to be enough. Therefore it were expressed as good that study tours, field visits and demonstration plots were increasingly being used in training and motivating of farmer groups. The trust for the extension service is strengthened according to many farmers that we met and farmers searched advices from specialists more often than before.

Field visits could also give farmers a chance of realizing what their practices could lead to. Mr Liymo also shared a story about farmers when seeing the surface of the Babati Lake growing believing it was because of more water and did not realise the big problem caused by erosion. Study tours were then conducted with farmers to areas where lakes had totally disappeared through siltation and they were convinced that they needed to stop erosion through changed practices.

Demonstration plots were also important for farmers that were not involved in a farmer group. It gave all farmers a change to see something different from the conventional practices in their own environment. Knowledge about things that could be easily practiced with a good and visible result such as FYM or intercropping maize with pigeon peas were spread fast and without formal activities.

9.6.3 Different value of knowledge

CA as a concept is often formulated by agricultural experts who believe in it as "THE way" of practising agriculture. We met farmers that had very different perceptions of the advises from experts. One way farmers were relating to experts' advice were that "experts' knowledge is good and a good farmer listens to it and acts on it", an opposite way were to think that "the first expert advice failed and I will not act on it again". What farmers in Babati District were doing was judged by experts on how well it fitted with CA. Farmers that were doing CA without any exterior support were celebrated as innovative and clever, while farmers that had skills and knowledge about CA but follow other ideas and concepts were regarded as stubborn and backwards. Some CA related practices were in fact methods that farmers used to practice in the past, but abandoned with a view to move towards a more modern farming. According to village extension officers (Workshop, 2005), some farmers would consider it as going backwards and therefore not worth changing to. There are reasons to believe that local farmers' knowledge is recognised and valued higher by experts acting as researchers or extension officers when it does not contradict the point-of-view of the experts.

9.7 GAPS AND CHALLENGES IN DIFFUSION OF CA IN BABATI DISTRICT

There are strengths in farmer group methods, demonstration plots and field visits but we also met things that restrained the diffusion process in Babati District.

9.7.1 Few extension officers with small resources

Asked about diffusion, village extension officers mentioned as a major problem having few extension officers but a big amount of farmers together with limited possibilities of transportation and communication in the area. This made it difficult both for farmers to go to the extensions as well as for the extension to reach the farmers.

9.7.2 Laggard farmers and extensions

Village extension officers and agricultural experts expressed that there were often, among farmers, a low interest for searching new knowledge and for changing practice – "many farmers are laggards". Farmers that we have met have gives us a different picture. It were also expressed that there had been a problem with extension officers not doing a proper job, effectiveness was increasing after an introduction of a stronger

follow up system at district level where extension officers had to report their monthly work.

9.7.3 Lack in cooperation and communication between NGOs

Through their funding and activities, NGOs tend to have had an important impact on what has been done in the villages. Through these activities knowledge have been spread. However, a problem we found was that there seemed to be a lack of communication and cooperation between different programs, NGOs and projects in Babati District. Among the interviewed farmers, some had sometimes been involved in many different projects. Also some farmer groups got lot of support while other farmers did not even know the activities existed. For example, one farmer involved in a farmer group had succeeded well in improving his farming practice through the support given by one actor- This farmer later received a price from another actor for being the best farmer in the village. Furthermore, the price consisted of a Magoye ripper that the farmer already had received through the first actor. During the workshop it was discussed that the resources could be much better used and spread among different farmers through better cooperation and communication.

9.7.4 Communication between farmers

As already mentioned, diffusion through groups seemed to work well and the impacts have been many and good. Further diffusion of knowledge outside the group relied mainly on informal relationships among neighbours, fellow farmers and friends. We met farmers that had a good contact with neighbours and who after receiving knowledge or coming up with ideas of changed practices with good impacts shared this knowledge with their neighbours. However, more often we met the opposite trend, that the agriculture-related communication and discussion between farmers was generally low. This is also expressed by Ljubinkovic (2002, s.29) when she describes the impacts of farmer groups under FIDE in Babati District:

> Low level of information circulation and exchange between seminar participants and other members of the villages limited diffusion of the impacts. The non-participants can be divided into three groups; the ones who had copied some visible and observable techniques, i.e. planting in lines and cow sheds construction; the ones who had not benefited at all, though they know the seminars took place; and those who did not even know of the seminar existence

Visible impacts could be seen and sometimes copied, but farmers did seldom ask what these impacts resulted from. “A bad field is condemned and a good field is blessed” could sometimes be a sufficient explanation and no questions were needed. Another reason expressed by some farmers was that the trust between farmers for some reasons was low since the colonial times. Before they often helped each other going from field to field and worked together, but not any longer.

In general farmers expressed that communication and sharing of knowledge within the family did occur and were important. It was expressed as good when more than one member in the family got the chance to participate in training activities. This made it easier to improve the farm even if a member of the family were absent during work activities on the farm. At the same time, the small resources in extension services might be better spend if the trained farmers were from different families.

9.7.5 New knowledge only through groups

One limitation seen with the group methodology were that it could be difficult for an individual farmer to receive training and knowledge. We met farmers interested in getting knowledge and support, but without belonging to a group they could not. They were told first to establish a group of twelve farmers and then they could receive training. Another limitation that could be discussed is if the methodology of farmer groups really reaches the poorest farmers. Often innovative and strong farmers were getting involved and then it was up to other farmers to follow what they practice but without support of any sort.

9.7.6 Literacy rate

In time for the study Babati District had a problem with adult illiteracy this had an impact also on the diffusion process. Seminars, written material and other training methodologies and situations will be more complicated when people do not now how to read and write.

9.7.7 Health

Illness within the family has impacts in every area of the daily life. We met farmers without the possibility to leave for village meetings or the farmer field day due to their family members' health. They then often missed the chances of getting information and knowledge given about agriculture on these occasions.

10 IMPACTS AND ADOPTION OF CA

Fredrik Löfstrand

CA is said to increase yields, be a labour saving and sustainable way of agriculture. The impacts that can be and are seen as an outcome of CA in Babati District varies from increased yields and thereby improved livelihood to problems with weeds as farmers practise reduced tillage. Most important reason for many farmers to change their practise seems to be the hope of increased yields. As many new and improved agricultural practises have been introduced in the district during the past years it could sometimes be hard to tell the exact impact that were gained from CA practises. This chapter is to describe the impacts and adoption seen during field visits and described by farmers during interviews.

10.1 IMPACTS ON YIELDS

10.1.1 CA related yield increase

The majority of farmers in Babati District had farming as their only source of income and was highly dependent therefore depended highly on the yields that they got. Changes in yields could therefore have a great impact on the farmer's life, especially for the small-scale farmers. When farmers changed from conventional agriculture to CA they often started by sub-soiling their fields. When the plough pan was broken the infiltration rate of water was improved and the plant roots could penetrate the deeper soil layers. After sub-soiling the yields increased according to interviewed farmers and Jonsson et al. (2003). When the plough pan was removed the plant could assimilate nutrients from the deeper soil layers that had not been available for the crops earlier. After some seasons the yields tended to decrease as these nutrients were used, this underlines the importance of adding fertilisers to the fields (Jonsson et al., 2003).

Efficient use of water was important for the farmers in Babati District as they often saw scarcity of water as one of the main problems in their farming. When the ripper was used farmers said that the water infiltration increased and that they got higher and more secure yields. Contour bounds did also have an impact on the yields as water and nutrient were kept in the field, as the run off were lower. Soil covers with crop residues or cover crops reduced the evaporation from the soil and kept it humid for a longer period. One farmer mentioned that when he began to intercrop maize with pigeon peas and started to use ox-plough, the maize yields had increased from 3 to 8 bags/acre. He had now realised that this could be due to the N-fixation and that the pigeon pea taproots could improve the soil structure. Other farmers had seen that the yields of pigeon peas decreased due to diseases and therefore used crop rotation and cultivated beans or other crops for some year and then cultivate pigeon peas again.

10.1.1 Improved agricultural practises

Other changes that farmers mentioned as reasons to improved yields were the use of certified and improved seeds. They also saw the importance of using crop varieties that were appropriate in the AEZ where the farmer was cultivating. Planting in proper spacing instead of planting zigzag as before and planting three seeds at each spot for a more secure germination also had a positive impact on the yield. Earlier the use of

FYM had been limited by both knowledge and the fact that the livestock had been grazing over a wide area. Today zero-grazing stables made collection of FYM much easier and the use of FYM had improved the yields.

Farmers that kept their livestock in zero-grazing stables also said that the milk production had increased and that the animals were healthier. The production increased as the animals were given better fodder and the farmers also had better control than before over how much fodder each animal got.

10.2 IMPACTS ON LABOUR

The farmers interviewed made most of the work on the farm themselves together with the family. In times for weeding and harvest some farmers hired labour and many farmers also hired tractors or draught animals in time for land preparation. Labours was either paid with money or given local brew at the pub in the village. When the crop was planted in straight lines weeding and thinning had to be done by more skilful workers that were paid with money. Some of the newly introduced practices were more time consuming than the old ones. To plant in straight lines and with proper spacing made the planting more time consuming than before.

10.2.1 Weeding

Weeding was usually done twice in Babati District. The first weeding was now more laborious as thinning had to be done. The second weeding was however done more easily as the crop stood in straight lines. With a proper soil cover the impact of weeds were low and weeding could be done easily just by picking the weeds by hand according to a farmer. Field infested by some of the more difficult weeds, for example couch grass (*Digitaria abyssinica*), a soil cover was not enough and these fields had to be ploughed or sprayed. The Magoye ripper was used for weeding between the lines and this made weeding less burdensome. It also gave the women less work as the husband and oxen took over the weeding. Some farmers also got an extra income from weeding others fields.

10.2.2 Tillage

In the conventional agriculture land preparation was done by hand, but more often with oxen or tractor. When oxen were used the field was tilled 1-3 times per season. Using the ripper the field only has to be tilled once. The crop residues as a soil cover made the tillage with the ripper more problematic as the crop residues were clogging the ripper beam. Before tillage the farmer had either to remove the residues from the field and then bring it back or open tracks for the ripper.

10.2.3 Zero-grazing

Animals kept free-grazing have to be watched during the day, keeping the livestock in zero-grazing stables was less laborious according to farmers practising zero-grazing. With zero-grazing they only had to collect fodder and not watch them as much as before.

10.3 ENVIRONMENTAL IMPACTS

Deforestation and erosion had been the main environmental problems in the district. When agroforestry was introduced the pressure on natural forests decreased and the forests were now recovering in many areas of the district. Using more economical stoves also reduced the demand of fuel wood.

Farmers had seen less erosion after establishments of contour bounds and after sub-soiling as the surface runoff decreased and soils where hindered from erode from the fields. Decreased erosion can halt the sedimentation in Lake Babati that had become larger but shallower during the past decades. Gully erosion had also damaged roads and fields in the area.

Recently many villages had introduced by-laws about tree planting, the impact of these by-laws time will show.

10.4 SOCIO-ECONOMICAL IMPACTS

The majority of households in the area where this study was conducted were poor or middle (Ringo et al., 2002). Many of the visited CA households visited during the study were given support of different kinds from projects to adopt CA. The possibility for weak poor household to adopt seems to be low as an adoption of CA demand knowledge, time and money. Changing to CA the farmer had to invest in sub-soiling, building of contour bounds, cover crops and so forth. To raise funds or take loans to make investments for a single farmer were more or less impossible at the time. The only opportunity to get a loan for the farmer was to be a member of a registered group of some kind and through this group the farmer could then take a loan. This was possible only to farmers in some villages in Babati District where i.e. SACCO-groups had been established.

10.5 IMPROVED LIVELIHOOD

Improved livelihood for small-scale farmers depended highly on the yields and the market for the agricultural products. A higher yield gave the farmer an opportunity to sell the surplus and their income increased. The increased income was for example used for secondary education for the children, building new houses or buy oxen. A higher production also led to less worries about getting food and the social climate improved as people became friendlier towards each other's. The way that the new agricultural techniques were taught, in groups, made the relations between farmers better and now they discussed agriculture with each other in a greater extent. Improved agricultural production as an outcome of extension officers' advices increased farmer's trust for the extension service and as a result farmers were now more frequently going to the extension officer for advices.

10.6 SUMMARY AND DISCUSSION OF IMPACTS AND ADOPTION

The three wards had a different history of CA and the adoption of CA was highest in Mamire ward. Mamire village was also one of the villages where FTP introduced agroforestry in the mid 80's. In Mamire ward the farmers that we met seemed to be

better off and had a somewhat brighter view on their agriculture. These conclusions might not give a fully true picture as we only met some few farmers in each village and the selection of farmers and our own approach give a somewhat monotonous picture of the reality. In Gidas farmers had small farms and there where now new land for the farmers to take into cultivation, while there in the other two wards were.

The most important impact seen and the reason for farmers to change practise was the increased and more secure yields. As the infiltration rate increased farmers could get a yield even during dryer years. One farmer said he got 24 bags on 4 acres using his direct planter while his neighbour only got 4 bags on the same area. This and other examples showed that there were a potential of increased production for farmers in Babati District. Several years of cultivation with insufficient application of fertilisers have led to low soil fertility and low yields. Farmers often took seeds for sowing from the previous year harvest, which also had negative effect on the yield. At the same time the compacted soils had led to a low infiltration of water that resulted in water stress.

10.6.1 Low adoption

Why was the adoption rate of CA still quit low even though it had been promoted in Babati District for more than ten years? The promotion started in a small scale and some farmers were introduced to reduced tillage and sub-soiling. CA had never been promoted as a full package in Babati District. The farmers that had started with CA practises were more or less all involved in groups. Even though farmers around the groups were interested in getting the knowledge about the "new agriculture" knowledge about it seemed to stay in the different farmer groups.

The interest of sub-soiling was high and knowledge about sub-soiling were widely spread. Sub-soiling were also subsidised by the district council. The price of ripper was higher than the mouldboard plough and few Magoye rippers had been sold to farmers in the district. Many of the rippers sold by TFA Babati had been sold to neighbouring districts. The knowledge about the benefits of using the rippers were maybe not fully understood or eventually, farmers saw sub-soiling as a solution for overcoming the problem with compacted soils that the ploughs caused.

Cover crops had recently been introduced and were more or less only used by farmers with demonstration plots. To get a good adoption of cover crops the cover crop probably have to give the farmer an extra income, as the case was with pigeon peas. The newly introduced cover crops lablab and velvet bean had problems concerning market and pest attacks that limited the adoption of these two crops.

It was hard to tell whether some of the impacts that farmers told us about were something they had seen or just the things they had learnt during training.

10.6.2 Effect of HIV/AIDS

CA has been stated as labour saving and maybe to be a solution for labour shortage. In *Conservation agriculture -as a labour saving practice for vulnerable households* Bishop-Sambrook et al. (2004) says that "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 crop, towards conservation agriculture". Farmers in Babati District however often said that to practise CA investments like buying a Magoye ripper and laborious building of contour bounds had to be done. The question is if a household affected by HIV/AIDS have the possibility to do these investments, the answer is most likely no. At district level,

however CA has the possibility to cover the labour shortage that HIV/AIDS might cause.

10.7 GAPS AND CHALLENGES OF IMPACTS AND ADOPTION

Farmers often practised agriculture similar to what was practised by their parents. A change in agricultural practise could therefore be a big step for the farmer and a big decision. Before adopting CA farmers liked to see if it was beneficial and worked in practise. Then they liked to try it in a small scale, this was something that were hard as small-scale farmers only relied on a few acres. After the decision to adopt CA, farmers often had problems getting the different implements like rippers and cover crops seeds. Farmers that left crop residues and established a soil cover sometimes had to incorporate the residues into the soil as there were only some few rippers available to hire and they could not afford to buy a new Magoye ripper.
Availability of some of the cover crops was limited (e.g. lablab and velvet bean) but as more farmers cultivate these crops the availability of seeds will probably increase.

To change practise and invest in new equipment farmers wanted to get loans, but this were often difficult as loans only were given to registered groups. The way towards CA includes many changes and therefore it would be good for farmers to learn how to plan for and make good investment to change their agricultural practise.

When farmers were asked about problems and limiting factors for their cultivation the seldom mentioned soil fertility, even though it were likely to be a problem as the application of fertilisers were low. The amount of rain was for most farmers the main limiting factor. They also often mentioned the poor market and availability of implements as problems. Awareness about soil fertility and the importance of nutrient recycling might be something that has to increase among the farmers

A problem in Babati District was the livestock and the post-harvest grazing that made establishment of soil cover and contour bounds difficult. If farmers get their contours and soil cover destroyed the motivation to continue with this practises might decline. Hopefully a wider use of soil cover and contour bounds will make the problems with livestock grazing in the field a minor problem. The lost source of fodder must however be replaced in some way and this brings a needed of improved pasture and new land for grazing.

In some areas farmer leased land on a yearly basis, the cultivation on this land was often done in an unsustainable way due to the short time period. The investment costs of for example building contour bounds, sub-soiling and tree planting in these fields does not give a return in one year. An improvement of the condition for the lease probably has to be done to encourage better agricultural practises on these hired fields.

11 COMPARISON OF CULTIVATION SYSTEMS

Fredrik Löfstrand

In this chapter, the small survey that was done to compare different soil fertility improvement practices is described. The chapter also includes a literature review where some soil properties, especially N, P and C contents in tropical environments are described and how the rate of these nutrients can be affected. In Babati District small-scale farmers replace nutrients lost at harvest only with FYM and to some extent with green manure and compost.

11.1 INTRODUCTION

The farmers in Babati District face many problems, but there are also possibilities. It rains too little and the rains are often irregular, says the farmers in Babati District and the market is not good either. Soil fertility is not often mentioned as a problem, but as farmers start to use FYM they can see an increase in yields and in some villages FYM has become so popular that it is almost impossible to buy it. When intercropping with pigeon peas, one farmer said his yields increased from 3 bags/acre to 8 bags/acre. These facts show to some extent that low soil fertility probably is limiting the yields

According to Jonsson (1996), the content of organic matter and availability of phosphorus is, in general, low in the soils in the district. Soil fertility is also stated as the second biggest constraint, after inadequate rainfall, to an increased agriculture production by the Government of Tanzania (Jonsson, 1996). If nothing is done about the soil fertility issue, food production per capita in Africa will continue to decrease even though other issues are not solved (Sanches et al., 1997).

One of the objectives of this MFS was to compare fields where CA was practiced with field where conventional agriculture was practiced. This was to examine the impact of CA in terms of infiltration, N, P and organic matter contents and pH. The intension was also to compare the weed impact. Due to time limitations and local circumstances the objectives that were set up in the proposal for the MFS for this part of the study had to be changed to some extent. After some weeks in Babati some of the questions at issue were rewritten according to circumstances met in the field. The initially idea was to select fields where CA had been practiced for a number of years. The fields should be in the same area with similar natural conditions. As CA is a wide concept and full-blown CA farmers are few, it was difficult to identify those fields. Another problem that was confronted in the studies was to identify fields receiving similar amount of FYM. About four kilometres East of Babati town the Waang'waray Farmers Training Centre were situated. This training centre was chosen to be a good local for conducting the comparison of different agricultural practices.

Main objectives were to examine how FYM affect soil fertility and the impact of intercropping under nitrogen fixating trees? How is pH and availability of nutrients affected? Can any differences be seen in C contents after years of leaving crop residues in the field? This study compares the yields from the three different agricultural systems. Are any of these systems recommendable to the farmers in the area and something the small-scale farmers can cope with?

11.2 LITERATURE REVIEW

11.2.1. Nitrogen

Nitrogen (N) is an essential element for all living organisms. It is a major part of all amino acids, which are the building blocks of all proteins including the enzymes. Plants take up N from the soil solution principally as NO_3^- and NH_4^+ ions. The leguminous plants, such as beans and soybeans fix atmospheric gaseous N (N_2). The fixating rate increase if the availability of N in the soil is low (Fogelfors, 2001).

According to Sanchez, (1976) a maize yield of about one tonne grain per hectare requires plant accumulation of less than 40 kg N per hectare and a four tonne yield requires 100 kg per hectare. Two thirds of this N will be accumulated in the grain and exported from the field at harvest (Sanchez and Palm, 1996). To compensate for the exported, N has to be applied, either as inorganic fertilisers or organic matter. The N content of four tonnes of leguminous leaf mulch dry matter ranges from 60 to 150 kg per hectare (Palm, 1995).

The amount of N in the soil is related to the level of organic matter (Twaha, 2004) and in agriculture system with no-tillage an accumulation of N in the soil surface can be seen. The uptake of N is lower in no-tillage systems than in conventional systems this can be related to an increased immobilisation of N by microbial biomass (Doran, 1980). According to Amado et al. (1998) the long term effect of the more efficient storage of soil N in the top soil from legume cover crop in no-tillage systems can lead to increased soil N available for maize and sustaining yields.

Fertilisers N utilisation is affected by the N source, this because NH_4^+ and NO_3^- ions have different effects on rhizosphere pH and uptake of other essential plant nutrients (Sigunga, 1997) The effect of N source on fertilisers N uptake and uptake of other nutrients are modified by soil characteristics such as native pH and nutrient status (Sigunga, 1997).

11.2.2 Phosphorus

Phosphorus (P) has an important role in the living cell and is, for example, an essential component in both adenosine triphosphate (ATP) and deoxyribonucleic acid (DNA) (Brady and Weil, 1999). The amount of phosphorus in the soil is often low, on average the upper 15 cm of 1 ha of soil contains 1000 kg (Brady and Weil, 1999). In highly weathered soils P may be the primary limiting nutrient for crop production (Linquist et al., 1997). A maize crop yielding four tonnes per hectare accumulates about 18 kg P, this can be compared to the amount of P present in four tonnes of leguminous mulches and green manures, which is 8 to 12 kg P per hectare (Sanchez and Palm 1996). Phosphorus is mainly lost through harvest removals or soil erosion (Sanchez and Palm 1996).

Phosphorus compounds in the soil are often unavailable for plant uptake (Brady and Weil, 1999) and the availability is highly affected by the pH. Optimal availability for plants is in the pH-interval 6,0-7,0 (Brady and Weil, 1999). P deficiency in the often acid tropical soil is usually caused by strong adsorption of $H_2PO_4^-$ to Al^- and mainly Fe^- oxides and hydroxides phosphate (Fontes and Weed, 1996). The adsorption of P in clays is also related content of goethite and gibbsite (Fontes and Weed, 1996). In alkaline soils soluble $H_2PO_4^-$ react with calcium and P is thereby made less available for plants (Brady and Weil, 1999).

The soils surface area affects sorption and soils with high clay content have a high rate of P sorption. Organic inputs enhance nutrient cycling, mineralization rates

and the transformation of inorganic forms of P into more available organic ones (Sanches, 2002). The microbial P turnover in Oxisols is determined by the biological activity rather than availability of inorganic P (Oberson, 2001).
Instead of cropping low P containing Oxisols by applying high doses of P fertilizers Oberson et al. (2001) suggests that a combination of low P fertiliser dozes and grass-legume pastures promotes P cycling and efficient use of P inputs. Application of manures and supply of plant biomass from tree fallows and legume rotations cannot reduce P deficiency on highly P-deficient soils (Buresh et al., 1997). Integration of organic-based systems and agroforestry with P-fertilisers may have a potential to increase availability of soil P (Buresh et al., 1997).

P requirement for a crop varies with species and production rate of the crop. The concentration of P in the soil solution that is needed for crop production varies from 0,003 to 0,03 mg/kg and for a maize crop with high yielding potential 0,05 mg/kg is needed (Fox, 1980). N_2-fixating legumes need a larger amount of ATP than other plants and a deficiency of P can therefore have a negative effect on N cycling (Giller and Wilson, 1991).

11.2.3 Carbon

Carbon has a very important role in all living organisms as building blocks in carbohydrates. In the photosynthesis plants binds carbon (CO^2) from the air and transformed it to different carbon compounds. The carbon is later released as the plant materials is used or wither and decompose (Fogelfors, 2001).

Most tropical soils are depleted of soluble carbon that microorganisms can use as their energy source (Sanchez, 2002). The amount of carbon in a soil is connected to biomass production and decomposition rate (Mokwunye et al. 1996). Micro biota us carbon as energy source and their activity regulates the nutrient cycling (Sanchez et al 1997).

11.2.4 C/N ratio

The C/N ratio affects the decomposition and recycling of nutrients. N and nutrients rich plant material increase the decomposition rate. If the plant material is poor in N and other nutrients the microorganisms use N from the soil solution and N is immobilised. Decomposition of plant material is as highest at a C/N-ratio of about 25-30. (Fogelfors, 2001)

11.2.5 Faidherbia albida (Acacia albida)

Faidherbia albida is a leguminous fast-growing tree reaching at maximum about 25 metres height and has an extensive taproot system that develops rapidly to reach an adequate moisture level (Saka, 1989). The tree has the slightly unusually property to retain its leaves during the dry period and shed them in the rainy season (Rwiza, 2005). Studies done in Malawi by Saka, 1989 shows that the soils under *F. albida* are highly fertile and the content of organic matter, nitrogen, phosphorus and the exchangeable cations (K, Na, Ca and Mg) are high. The soils pH was almost neutral, while the CEC values also were high, confirming the well-buffered fertile statues of the soils. High soil fertility under *F. albida* has been contributed to the nitrogen fixation and extraction of nutrients from deeper soil layers by the tree roots. The nutrients are returned to the soil from the tree litter when the tree shed its leaves. One benefit with the properties of *F. albida* and the shedding of its leaves is that it give partial shading from the branches and mulch from the leaves on the ground, this reduces heat stress and evapotranspiration which contribute to early season survival of

crops and improves the yields. (Staka, 1989) Millet cultivated under *F. albida* gave about 2,5 times higher yields than millet not cultivated under *F. albida* (Le Houérou, 2005).

11.2.6 Farm yard manure and application

FYM contain essential nutrients (N, P and K) and organic matter, effecting e.g. cation exchange capacity, water infiltration and pH (Lekasi et al., 2001) and can therefore improve soil quality. During the field study farmers expressed that FYM where used as fertilisers and as bedding material for the livestock. Not all farmers spread their animal's manure on the field.

In a study done in Kenya, Lekasi et al. (2001) found that the nutrient concentration varied considerable, see table 11.1. On average the manure contained 0,30 % P; 1,12 %N and 1,96 % soluble C.

Table 11.1 Content of nutrient in FYM

	P (%)	**N (%)**	**Soluble C (%)**	**Organic C (%)**	**C:N ratio**	**Tot. mineral N (mg/kg)**
Mean	0,30	1,12	1,96	24,4	21.8	494
N	279	281	280	281	281	141
Min	0,06	0,33	0,12	6,5	19.7	24
Max	0,75	1,91	7,98	49,2	25.8	1685
SD	0,11	0,33	1,30	8,8	9,7	530

n= number of samples analysed; SD.= standard deviation (Lekasi et al., 2001).

11.3 WAANG'WARAY FARMERS TRAINING CENTRE

11.3.1 Geographical features

The centre is situated about four kilometres from Babati town on the road towards Mamire ward on the foot of Mount Kwaraa. The altitude is about 1 400 m A.s.l. The rains are bimodal and the yearly precipitation ranges from 700-900 mm/year. The soils in the area have been classified as Latosols (Oxisols) (Chamshama et al., 1993). The natural vegetation is degraded due to cuttings and grazing. The dominant trees are *Acacia* sp., *Dodonea* sp., *Brachustegia* sp. and *Combretum* sp. (Chamshama et al., 1993).

11.3.2 Short history of the centre

The Waang'waray Farmers Training Centre was established in 1993. Before that the land had belonged to the farmers in the village. At this time the land was severely degraded and first was contour bounds established and trees, shrubs and fodder grasses planted around the fields and on the contour bounds. Cultivation of the land began in 1995 and the area was then divided into 5 major plots that were divided into sub-plots. An arboretum was also established nearby.

11.3.3 Cultivation systems

The natural ecosystem is destroyed as the land is taken into cultivation and the circulation of nutrients is interrupted as the nutrients are exported from the field. Today the return of nutrients to the fields in Babati District is low and use of inorganic fertilisers among small-scale farmers are more or less non-existing. To

establish a good nutrient conservation a high content of organic matter, preservation of aggregated soil structure, large investments by plants in below ground tissues and often slow growth are important (Kellman and Tackaberry 1997). According to Kellman and Tackaberry (1997) crop removals of calcium and magnesium can probably be offset by net inputs on those tropical soils that contain weatherable minerals in the upper solum, including alluvial and recent volcanic soils, Vertisols and those on limestone terrain and the input of potassium is probably also sufficient to offset losses in basic food crops. In permanently farmed fields can however a nitrogen and phosphorus deficiency occur as weathering and atmospheric sources cannot correspond to the losses after harvest (Kellman and Tackaberry 1997).

At the training centre several different agriculture systems are demonstrated, the ones that are compared in the study are the only ones described in this report. Tillage is done with oxen and Magoye-ripper and every third year the fields are sub-soiled. FYM is broadcast during the dry period (August to October) and sowing is done in December or January after at least 40 mm of rain. The seeds are put in straight lines with the help of a thread with knots on together with spot application of a mixture of FYM and soil. First weeding is done 14 days after sowing and unwanted plants are removed, some plants are kept as green manure. A month later the second weeding is done. Rock phosphate has been applied twice, year 1999 and 2001.

On plot 1 A, B and C FYM (5 tonnes/ha) is applied each year and this year maize were cultivated. On plot 3 maize was intercropped with a legume, this year *Lablab purpureus*, under *Faidherbia albida* (*Acacia albida*) FYM were applied at a rate of 5 tonnes/ha. On the plots 2A, B and C maize were cultivated without any intercropping or application of FYM.

11.4 MATERIALS AND METHOD

11.4.1 Soil sampling and analyse

Soil samples were taken randomly in seven of the centres demonstration plots. The samples were taken from the upper soil layer, 0-15 cm, to agree with the methods used earlier years. An auger was used to take the soil samples and five sub-samples were taken in each plot (see figure 11.1) and mixed in a bucket to make up the compost sample for that specific plot. In total nine compost samples were taken.

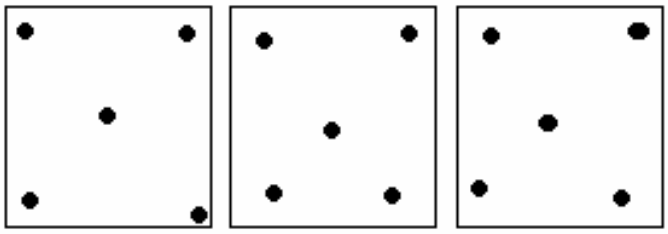


Figure 11.1 The way the sub-soil samples were taken in each plot

The soil samples were then dried on paper sheets on a roof terrace for almost two days. Then the soil samples taken at Waang´waray were sent to the laboratory at Sokoine University in Morogoro. There the following analyses were done:

- Soil pH in water
- Total N (Kjeldahl)
- Total C (Walkley and Black)
- P (Olsen-P when pH > 7,0 and Bray-1 when pH <7,0)
- Soil texture, i.e. total clay, total sand and silt.

Statistical analyses of the soil analysis result were done with Microsoft Excel.

In addition to this a literature review about *F. albida* and N, P and C that this study looks into was done.

11.5 RESULTS

In conventional agriculture in Babati District the main part of the produced biomass is exported from the field and used as food, fodder, fuel wood etc. Animals are either post-harvest grazing or kept on grazing areas. As the livestock are grazing over large areas, collection of manure is rare in the conventional farming practices and recycling of nutrients is therefore traditionally low. The number of farmers keeping their livestock in zero-grazing stables is increasing and collection of manure and nutrients can easier be returned to the fields. From the extension service in Babati District efforts are done to promote crop rotations with legumes to improve soil fertility and to keep the soil covered to decrease erosion and run-off.

11.5.1 Soil characteristics

In the comparison between the three different treatments variations in N, P and pH can be seen. The highest N-level is found in the *F. albida* plot (plot 3) that contained 0,15% N and lowest in the unfertilised plot (plot 2), 0,09% N. The difference between the plot is significant on *** level, according to the statistical analyse done. In the unfertilised plot the amount of N has decreased compared to the level in year 1997 when the soil contained 0,14% N. A small increase can be seen in plot 3 were N has gone from about 0,115 to 0, 150 %.

In year 2005 P content differs a lot between the three plots and the amount of P have increased in plot 1 and 3 while there is no significant difference in plot 2. The plot under *F. albida* has the most marked increase from about 0,9 mg/kg to 35,8 mg/kg. The N_2-fixing plants are capable of dissolving soil Ca-P, since the process of fixing N also acidifies soil. The effect soil acidification is not evident in the treatment that increased available P. This is probably due to rock phosphate, which was applied, implying the acidity generated during N_2-fixation was neutralized by rock phosphate.

Table 11.2 Average values from the analytical data for the three plots from three different analyse occasions.

Year (plot)	pH (H_2O)	Total N (%)	Available P (mg/kg)	OC (%)	C: N	Clay (%)	Silt (%)	Sand (%)
2005 (1)	7.48	0.14	10.56	1.67	11.95	47.33	8.33	44.33
2005 (2)	6.77	0.09	0.92	1.30	15.00	48.00	7.67	44.33
2005 (3)	7.51	0.15	35.79	1.78	11.87	44.00	7.67	48.33
1997/98 (1)	5.08	0.13	1.12	-	-	36.25	27.72	37.70
1997/98 (2)	5.07	0.15	1.78	-	-	36.52	31.37	32.12
1997/98 (3)	5.6	0.15	0	-	-	35.50	14.90	49.60
1997 (1)	5.17	0.13	1.02	1.19	9.38	-	-	-
1997 (2)	5.40	0.14	1.02	1.37	9.77	-	-	-
1997 (3)	5.55	0.115	0,90	1.53	12.90	-	-	-

(1997 and 1997/98 data from LAMP and Babati District council)

OC have increased with about 40% in plot 1 and with about 16% in plot 3. In the control the trend is opposite and a slightly decrease is seen. These changes are however not significant according to the statistical analysis. The only significant difference in OC level appears between plot 2 and 3 were plot 3 contains more OC, significant on a 5%-level.
In comparison between the different fertiliser practices it is seen that pH is higher in plot 1 and 3, about 7,5, in the control unfertilised plot 2 pH is about 6,8. As mentioned earlier, pH was raised by liming.

Table 11.3 Recalculated yields for the plots in kg/ha.

Plot nr	**1995/96**	**1997/98**	**1999/00**	**2003/04**
1A	4882[1]	2 626[1]	1037.4[1]	2784.8
1B	4154[2]	5375[5]	2596.3[4]	3482.1
1C	5324[3]	3950[3]	1441.5[3]	2866
Average yield crop	4786.7 maize	3983.7 maize	1691.7 maize	3044.3 millet
2A	4691[1]	991[1]	847.8[1]	1086.9[5+]
2B	2802[2]	3072[+]	1210.7[4]	986.51[+]
2C	3507[3]	1195[3]	193.7[3]	145.3[3] ∘
Average yield crop	3666.7 maize	1752.7 maize	750.7 maize	739.6 maize
3A,B and C	2916[3a]	56	1601.2[7b]	2816.2[7]
Crop	maize	beans	maize	maize

[a,b] intercropped with pigeon peas
[a] + litter
[b] + rock phosphate
[1]CG 4141 maize
[2]H-632 maize
[3] Kilima
[4]Pannar
[5]SC.627
[6]H-622
[7]Pioneer
[+]sub-soiled
°not sub-soiled

(Data from LAMP and Babati District council)

11.5.2 Yields

The average maize yield in Babati District from the period 1994-2004 is 1800 kg/ha, see appendix 8. The non-fertilised plots have during the last years given low yields, about 1000 kg/ha. The other two plots give yields above Babati District average. According to the data given from the Farmers Training Centre in Waang'waray plot 1 gives the highest maize yields.

11.6 DISCUSSION AND CONCLUDING REMARKS

Higher yields are, for the farmer, the most important factor for changing his/her cultivation practice. The difference in productivity between the plots in the study is big and as expected the unfertilised plot 2 give very low yields. The other two plots give yields higher than average yields in Babati District. The variations in yields over the years are affected of variety of maize cultivated, soil fertility and precipitation rate. Waang'waray is situated in an area with generally low precipitation and water shortage can some year lead to low yields.

Initially pH in all three plots was low and had probably decreased with a continuous use of FYM. Applications of rock phosphate have however had an impact on pH. 1997 all plots were acid with a pH below 6,0. This study shows how pH has increased in all plots and pH in plot 1 and 3 are now about 7,5 and 6,8 in plot 2. For plant cultivation a pH between 5,5 and 7,0 is most suitable a higher pH will e.g. result in a reaction between $H_2PO_4^-$ and calcium (Brady and Weil, 1999) and make P unavailable for the plant.

Application of P is highly needed to soil under cultivation as soil in the tropics often are low in P and P is exported from the field with the harvest and also lost through erosion. Green manure does not normally replace the P lost in harvest and erosion, and therefore P must be added through other sources. This study does not answer whether application of FYM and green manure are enough to cover these losses, as rock phosphate were added to the plots. According to Lekasi (2001), FYM from various farms in Kenya contained about 0,30 % P. At Waang'waray 5-10 000 kg/ha of FYM is applied (probably) each year, giving an addition of 15-30 kg P per application. If the FYM is of mean quality an application of about 4 500 kg/ha would cover a harvest of about 3 000 kg maize/ha. The result from the study shows that the rate of P has increased in plot 1 and 3. All added P has not been used and P has accumulated in the soil. The content of P is highest in plot 3 and as expected lowest in the unfertilised plot 2. The high P content in plot 3 could be due to the uptake of P from deeper soil layers by *F. albida*. P has the highest percentage increase of the different factors analysed.

To apply enough N to a field where maize is cultivated through adding green manure demands an application of about four tonne. This green manure has to be taken from outside the field and transported to the field. To only rely on legumes fixation of nitrogen to compensate for looses in an intense cultivation system is not possible. The production area of green manure has to get nitrogen to compensate for the losses that occur when biological material is removed, this to keep the productivity of green manure. In plot 2 the amount of N has decreased as a result of the export of nutrients via harvest and the fact that no FYM or nitrogen fixating plants have been used in these plots. In the other plots the N-levels have increased and at the same time export of nutrients are likely to have increased as a result of greater harvests in these plots. There is a significant but small difference in N-level between plot 1 and 3. This difference could be expected to be greater as plot 3 is under the nitrogen fixating tree *F. albida* and legumes are intercropped with the main crop.

Typically, N is vulnerable to leaching losses. It is probable that some N was leached from the topsoil sampled. The rate of N-fixation by legumes is also decreasing, if there is a sufficient amount of N in the soil.

The C:N ratio in all plots are low due to low content of organic matter. A low C:N can be expected as the turnover rate is high in the tropics and the applied FYM

and biological matter contain a high ration of N. The application of N-rich biota is missing in plot 1 and can therefore be a reason for the higher C:N ratio in this plot.

The study shows the importance of recycle nutrients and increasing soil fertility to raise the crops production. Use of rock phosphate was beneficial in terms of improving available P and pH and should probably have a positive impact on many small-scale farmers production in Babati District. The soils in the District have, however, a wide range of properties and this should be taken in consideration before recommending application of manure and especially as rock phosphate can be a big investment for some farmers.

P is also needed when a leguminous crop that is cultivated to improve the soil as N-fixating plants have a higher demand of P. In the plots where neither legumes nor FYM have been used the amount of N have decreased while P remained similar to the initial value, due to applied rock phosphate.

F. albida improved the conditions for crops growing under the trees, giving shade and keeping moisture to some extent. Some of the mechanisms by which these plants improve available P in soils are by producing acidity which dissolves calcium phosphate and by mining P from deeper soil layer and transferring it to the topsoil. These trees are well adopted in many tropical areas and are also promising the area these studies were performed. Moreover some of the trees have multiple uses: soil fertility improvement; fodder and fire wood.

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Mr. Kavishe, LAMP
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Mr. Masalogo, FA
Mr. Mbise, SMS
Mr. Msaba, SMS
Ms. Msofe, DALDO
Mr. Rwiza forest officer Waang'waray Farmers Training Centre
Mr. Sokoitan, IATC

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APPENDICES

APPENDIX I

GUIDELINE FARMER INTERVIEW

Start to describe our study, our aim and interest with the interview

Walk the farm together

Let the farmer talk about his farm

Create a farm sketch

Start from what has been seen on the walk
Talk about fields further away, owned and hired
Talk about total size of the farm
Talk about crops
Talk about the family, children, adults

Create a timeline

Start from a specific time we have been talking about
Talk what has been happening in life and on farm since then
Education
Farm changes
Start using CA-technologies/principles, find reasons
Eventually stopped using CA-technologies, find reasons

Depending on time or at a second visit

Create a seasonal calendar

CHECKLIST FARMER INTERVIEW

Village

FARM SKETCH

Name Age Sex
Household size/composition
Size of the farm (owned and hired)
Fields/Fields farmed with CA
Crops grown

TIMELINE

Education
Started farming on this land
Participate in CA-related activities
Time started with CA
Reasons for decisions made concerning techniques used
Perceptions of CA
Visible impacts of CA
What it took to learn CA
Individual changes made of CA
Time stopped using CA
Reasons for decisions made

If participate in CA-activities but never adopted
Reasons for decisions made
Perceptions of CA

SEASONAL CALENDAR

Time for land preparation
Time for planting
Time for weeding
Time for spraying
Time for application of fertilisers/manure
Time for harvesting

Techniques used for land preparation
Techniques used for planting
Techniques used for weeding
Techniques used for spraying
Techniques used for application of fertilisers/manure

For above:
Why / reasons for doing
Labour inputs
Who does what?
First / good / bad year

Wherefrom comes:
Seed
Pesticides/Herbicides
Fertilisers Tools
Labour Yield

APPENDIX II

Report from the mid term review

Introduction

The midterm review on CA was conducted on the 21st June 2005. The objectives of the midterm review were as situated below:

- To assess to what extent the planned objectives of the CA case study have been achieved.
- To see if there were any constraints encountered during the implementation of the case study, and strategies to elevate these constraints.

Study Methods

The CS focussed on three wards, namely: Mamire, Gidas and Mwada. The study also involved agricultural related non-governmental organisations. In the wards farmers were interviewed on the concept of CA.

General discussion

The students who participated in the study on CA elaborated the aims of the CS. They indicated that, at the end of the CA CS they should come up with :

- Current status of CA in Babati
- The extent of adoption of CA in Babati
- The reasons which have led to high or low adoption of CA
- Challenges with adopting CA
- History of CA in Babati
- Key actors in CA diffusion
- Roles of non-governmental organisation in CA diffusion processes
- The role of the government in CA diffusion
- Impacts of CA
- Situation before CA

The students presented their study based on the above objectives. Midterm review participants discussed the presentation and made some constructive contributions to the study. The contributions were adopted by the students and would be used to improve the CA CS. The midterm review indicated that:

- More information should be collected on impacts of CA
- More interviews should be carried out

Feedback workshop should be conducted

APPENDIX III

WORKSHOP WITH EXTENSION STAFF, NGOS AND FARMERS

Approximately 20 people (12 Farmers, 5 Extensions and 3 NGOs) will be invited to the CA CS workshop.

Selection of farmers to invite will be done on the following criterions:

CA-champions for each farmer group (one man, one woman)	4
Farmer without much CA-experiences	2
Trained but doesn't practise much CA	4

Farmers with specialization (training, area of knowledge for example organic- farming)

Among the farmers there should be a good mixture of young and old farmers, women and man. A gender ratio 2:4 at least

WORKSHOP SCHEDULE

9:30 INTRODUCTION

- PRESENTATION OF US
- PRESENTATION OF THE STUDY
- WHAT IS CA, our definition of CA
- WHY DO WE HAVE A WORKSHOP

GROUP FORMATION

Divide the workshop-participants in 3-4 groups (Farmers, Extensions and NGO's)

Every group should have a group leader to lead the discussion and to give a summarize after each discussion.

SUBJECTS FOR DISCUSSION

9:45 – 10:45 PART 1
Aim: to understand what knowledge and perception different actors hold of CA
Time:

- **Introduction from team 5 min**

Introduction of CA and what we have seen of CA in Babati District

- **Give every person 5 min to think through the questions and write down thoughts**
- **Let every person in the group share without interruption his/hers own thoughts, 2 min/person**
- **Discuss in the group 10-15 min**
- **Share in big group and discuss**
- **Summarize, by team**

10:45 - 11:15 Tea – break

11:15 – 12:30 PART 2
Aim: to find farmers, NGO's and village extension officers perceptions on problems and solutions for farming in Babati District

Time:
Introduction from team 5 min
Describe the problems affecting the farming practice found in our study as well as changes in the practice that has led to a positive impact on the problems

- **Give every person 5 min to think through the questions and write down thoughts**
- **Let every person in the group share without interruption his/hers own thoughts, 2 min/person**
- **Discuss in the group 10-15 min**
- **Share in big group and discuss**
- **Summarize by team**

Lunch 12.30 – 13.30

13:30 – 14:30 PART 3
Aim: Find strengths/weaknesses in the diffusion and adoption process

Time:
Introduction from team 5 min
Describe what we seen of extension/NGO work and activities to train and motivate farmers to adopt CA. Describe problems/limitations that effects the adoption. Describe also the actors and the methods used by NGOs and extension service and problems seen in collaboration and with spreading of knowledge

- **Give every person 5 min to think through the questions and write down thoughts**
- **Let every person in the group share without interruption his/hers own thoughts, 2 min/person**
- **Discuss in the group 10-15 min**
- **Share in big group and discuss**
- **Summarize by team**

14:30 – 15:30 PART 4
FINAL SUMMARIZE
-What would be the best way forward for CA in Babati District?

Big group discussion

QUESTIONS FOR DISCUSSION: VILLAGE EXTENSION OFFICERS

PART 1
What is the definition of CA for you? How does your definition match our definition?

Discuss positive/negative things with CA as a concept and with CA as independent techniques

PART 2
What are the possibilities/limitations with farming in Babati District?

In what way, through what means can farmers improve their farming practice in Babati District?

Discuss if CA is a suitable solution for improving agriculture in Babati District, are there other and better solutions?

PART 3
Is the knowledge about CA sufficient among the village extension officers to give farmers good guidance? (If no, what needs to be strengthened?)

Do you consider the extension service and its working methods to be an effective tool in the diffusion process? (Discuss how it could be improved and strengthened further)

What can be done by NGOs, village extension officers, farmers and politician's to strengthen and increase CA adoption?

QUESTIONS FOR DISCUSSION: FARMERS

PART 1
What is the definition of CA for you? How does your definition match our definition?

Discuss positive/negative thoughts and experiences with CA as a concept and with CA as independent techniques

PART 2
What possibilities and limitations do you see in your farming practice? How can/have you improve/d your farming practices?

Discuss if CA is (has been) a suitable solution for improving your farming practice, are there other and better solutions?

PART 3
What are the needs for farmers to adopt CA?

What hinder a fast and wide adoption of CA among farmers in Babati District?

What can be done by village extension officers, farmers, NGOs and politician's to strengthen and increase CA diffusion and adoption?

QUESTIONS FOR DISCUSSION: NGOS

PART 1
What is CA for the NGO that you represent? How does that definition match with our definition?

Discuss positive/negative things with CA as a concept and with CA as independent techniques

PART 2
What are the possibilities/limitations with farming in Babati District?

In what way, through what means can farmers overcome different hinders to develop their farming practice?

Discuss if CA is a suitable solution for improving agriculture in Babati District, are there other and better solutions?

PART 3
What can be done by NGOs to strengthen and increase CA adoption in Babati District?

What can be done by other actors (politicians, SMS's, village extension officers, farmers)?

How can the collaboration be improved between SMS, village extension officers, NGOs and farmers?

APPENDIX IV

Questionnaire for village extension officers

This survey is about knowledge and experiences concerning Conservation Agriculture (Kilimo Hifadhi) related techniques and implements in Babati District and how it is diffused and adopted in the area.

Some questions below are concerning farming practices - tillage techniques, planting, application of manure, cropping pattern/rotation, weeding techniques and use of crop residues.

Write your answers on the provided lines and encircle Yes/No (ex. Yes-answer (Yes)/No)

How old are you? _____ years □ male □ female
What is your level of education?
_____
How many years have you worked as a village extension officer? _____ years

Do you have a farm yourself? Yes / No Size:_____ acres
If you have a farm, describe your farming practises:
_____
_____
_____

What are the main crops grown in the village? _____
What are the main soil types in the village? _____
What is the annual rain in the village? _____

How often are you in contact with farmers from your village? _____ days a week

What is the percentage of the farming population on the village which is in frequently in contact with you? □ 0-25% □ 26-50% □ 51-75% □ 76-100 %

In what form is the main contact between you and farmers? (rank from 1-4, 1 for most common)
__ individual __ farmer groups __ village meeting __ other:_____

What are the main reasons for farmers coming to you? _____
_____
_____

What are the main reasons for you going to farmers? _____
_____
_____

What changes in the farming practices have you seen in your village in the past?
_____
_____

What can farmers in your village do to improve their farming practice? _____
_____
_____

What are the possibilities and limitations for further improvement of the farming practices in your village? _____

APPENDIX V

Summary of answers from questionnaire

25 questionnaires were distributed to extension officers and 14 were returned. The extension officers in the survey were divided on eleven men and three women. They were from 38 to 45 years old (mean age of 45 years). They had worked as extension officers from seven up to 32 years (mean time 18 years).

Extension officers farming practices

The village extension officers in this survey are in general preparing their land by tractor or oxen drawn ploughs and using hand hoe for weeding. One mentions that the Magoye ripper is used for land preparation, planting and weeding. Many have sub soiled their land and constructed contours. Crop residues are left on the field after harvest by some, and a few are also using cover crops. Intercropping and crop rotation are practiced by most of the extension officers.

Crops grown

Crops mentioned as grown in the villages were: (Number of answers)

Maize (13)	Sweet potatoes (1)	Green gram (1)
Pigeon Peas (13)	Wheat (1)	Finger millet (1)
Beans (11)	Cotton (1)	Cassava (1)
Sorghum (7)	Simsim (1)	Banana (1)
Sunflower (6)	Lablab (1)	Coffee (1)

Extension officers contact with farmers

Extension officers main contact with farmers were through farmers groups other then that they met farmers through village meetings and individual meetings, few extension officers also mentioned farmer field days, ward meetings and leaflets as ways of interacting with farmers. Most (9 of 14) extension officers said they were frequently in contact with 51-75 % of the farmers in their village.

Reasons why farmers come to the extension officer

Generally farmers came to the extension officers when they had problems with sick animals and pests. They also came for advice on crop production/new varieties of seed. Few extension officers also mentioned that farmers came in case of conflicts between farmers and livestock keepers and for credit and funds for their agricultural practices.

Reasons why extension go to farmers

Generally extension officers are going to farmers to give them technical advice. They use words as advice, bring, deliver, sending messages, disseminate and educate improved agriculture and new research or innovations. Some extension officers are also going to farmers to listen, evaluate and learn what problems the farmers have.

Changes seen in the village

In general improved seed, FYM, contour and sub-soiling is the major changes done according to the survey. Some farmers have started to use the Magoye-ripper and some farmers use chemicals but still very few. Mentioned are also agroforestry, crop rotation, proper spacing, zero grazing, improved pasture establishments and a higher number of established farmer groups.

How farmers can improve their practices

Application of FYM and certified seeds are the most common answer on the question how farmers can improve their farming. Constructing contours and subsoil their land is another way forward according to the survey. Other things mentioned is the use of the Magoye ripper, leaving of crop residues in field and cover crops, no after harvest grazing. Some also say that farmers should join farmer groups. There are also less specific answers as apply good farming practices, soil and water conservation and CA.

Possibilities and limitations for improvement

The most common limitations mentioned are poverty together with expensive inputs, draught and poor knowledge and education. Other things mentioned as limiting for farmers to improve is overgrazing, high population pressure, ignorance, unreliable market, lack of inputs and implements.

The most common possibilities mentioned are a repetition of the things mentioned on how farmers can improve, applying certified seeds, FYM etc. Also here farmer groups are mentioned as a possibility together with micro finance groups as the SACCOS so that farmers can get loans. One extension explains in contrary to the one saying farmers are ignorant that the mindset of the farmers is already changed and change will therefore come easy

APPENDIX VI

Data of villages visited for the study

Table of Data *Farming Systems Babati KIL/BBT/FS[9]

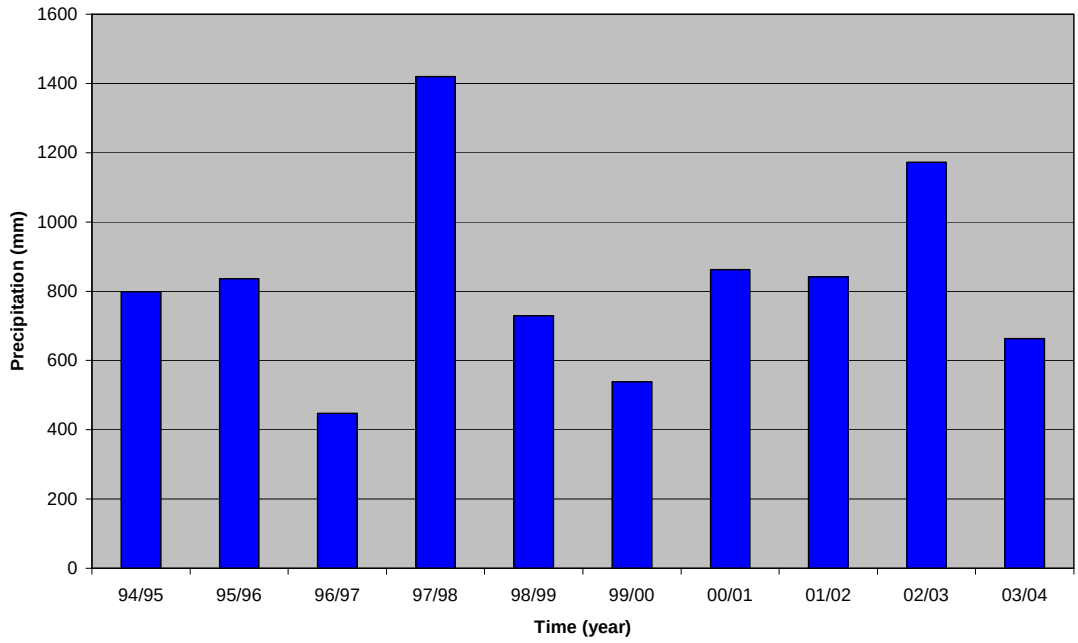
Village	Endakiso	Gijedabungh	Gijedaboshka	Mwada	Mamire	Boay
Population	3372	950	1760	3150	3000	1376
Households	786+	450+	270+	661+	400 check	267-
Average household size	No info	No info	No info	2-3 pers	No info	5
Ethnic groups (%)	Iraqw – 60 Arusha - 20 Rangi – 10	Arusha – 45 Iraqw - 25 Nyaturu – 15	Rangi – 55 Gorowa - 35 Iraqw - 5	Gorowa - 60 Nyiramba - 25 Nyaturu - 15	Rangi – 45 Iraqw – 40 Gorow – 10	Gorow – 45 Iraqw – 30 Rangi – 25
Village area (ha)		4220	2400	15520	2885	1286
Used area (ha)	5032	3520	1504	2400	1400	364
Average farm size (acres)	No info	No info	2-3	2-3	3	No info
Crop grown (ha)	Maize - 1716 Bulrush millet - 24 Beans - 858 Sweet potatoes - 4 Cassava - 6 Pigeon peas - 1520 Sunflower - 858 Finger.millet-no.info	Maize Sourghum Beans F.Millet P.Peas	Maize – 520 Sourghum - 60 Beans - 120 Banans - 20 Cassava - 8 S.Potatoes - 18 P.Peas - 520 Coffee - 10 Sugar cane - 8 F.Millet – 100	Maize - 500 Sorghum - 500 Cotton - 150 Sunflower - 100 Simsim - 20 Paddy - 20 Millet - 3.2	Maize - 420 Millet – 60 Beans - 140 S.Potatoes - 2 P.Peas – 200 Sunflower – 205 Cotton - 4 Sourghum – 67 F.Millet - 9	Maize - 200 Beans - 200 S.Potatoes - 6 P.Peas – 100 Sourghum – 108 F.Millet - 40 Banana – 160 Coffee – 40 Casava – 6 Sugarcane - 4
Cropping pattern	Intercropping of: Maize/P.Peas Beans/Sunflower	Intercropping of: Maize/P.Peas Beans/P.Peas	Intercropping of: Maize/P.Peas Maize/Sourghum Sourghum/P.Peas Coffee/Banana	Intercropping of: Sourghum/Maize Maize/P.Peas	Intercropping of: Maize/P.Peas	Intercropping of: Beans/Sourghum Maize/Banana Beans/P.Peas
Type of livestock numbers?	Cows Draught animals Sheep Goats Impr. dairy cattle Donkeys	Cattle-451 D.animals Sheep-202 Goats-350 Impr.Dairy Impr.Bulls Donkeys Pigs	Cattle-1082 D.animals-250 Sheep-192 Goats-408 Impr.Dairy-5 Impr.Bulls-3 Donkeys-58	Cattle-1500 D.animals-15 Sheep-2300 Goats-4000	D.animals Pigs Goats Donkeys	Cattle - 1800 D.Animals – 200 Sheap – 148 Goats – 653 I.Bulls – 1 Donkeys – 26 Pigs - 5
Households with cattle	No info	No info	75%	80 %	90%	No info
Poor/middle/rich %	59/36/5	No info	68.35/24.36/7.27	71/24/5	68/30.4/1.6	68/30/2

[9] Refinement of farming systems and agro-ecological zonations of Babati District and development of resources database, Ringo.D.E, et.al, 2002 Ministry of Agriculture Republic of Tanzania

APPENDIX VII

Yearly precipitation

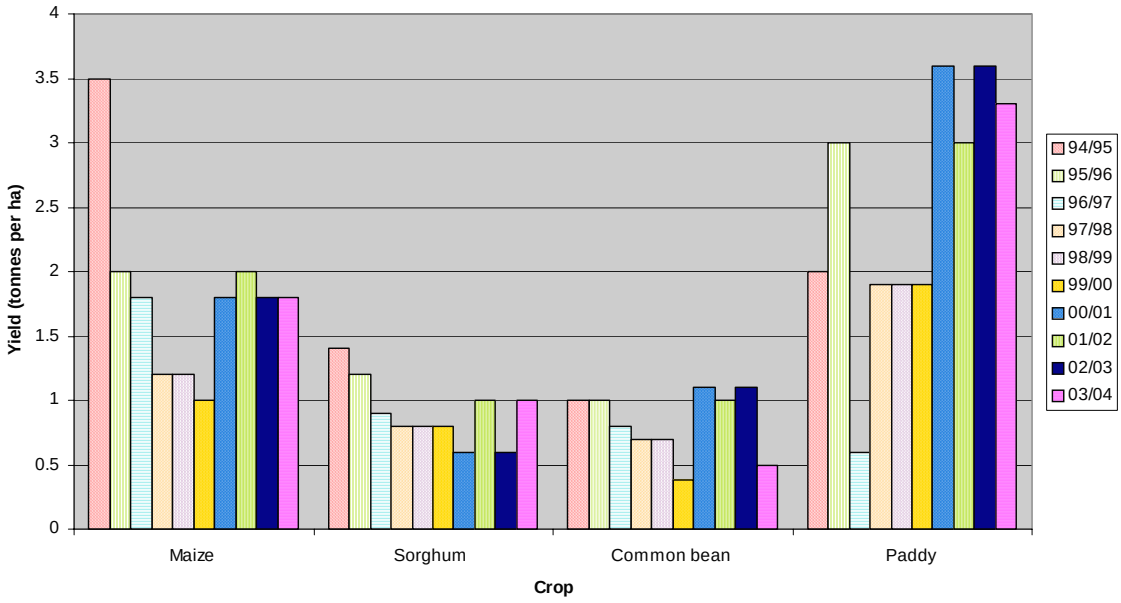
Diagram over the yearly precipitation rate (July to June) in Babati town during the period of 1994/95 to 2003/04 (Babati District Council, Agriculture Office, 2005).



APPENDIX VIII

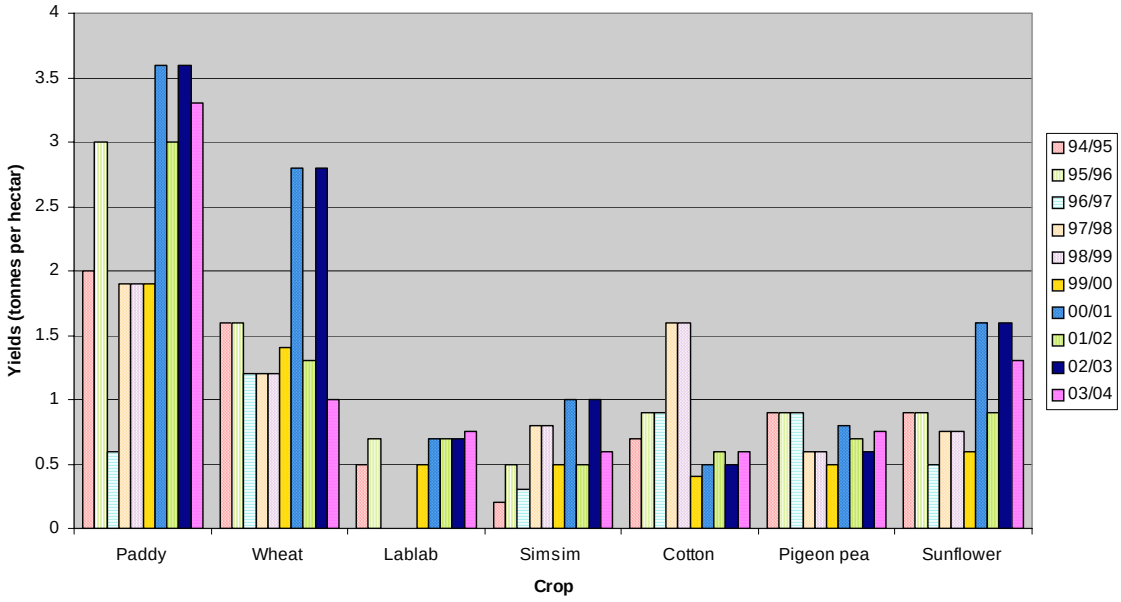
Yearly food crop yields

Diagram over the yield variation of four food crops during the time period of 1994/95 to 2003/04 (Babati District Council, Agriculture Office, 2005).



Yearly cash crop yields

Diagram over the yield variation of seven major cash crops during the time period of 1994/95 to 2003/04 (Babati District Council, Agriculture Office, 2005).



APPENDIX IX

AN EXCERPT FROM THE
OPERATIONAL FRAMEWORK & GUIDELINES
FOR USE WITHIN THE CONTEXT OF THE
CONSERVATION AGRICULTURE CASE STUDY PROJECT
(The original version was prepared by Bernard Triomphe, CIRAD, May 1, 2005)

I. BIOPHYSICAL, SOCIOECONOMIC & INSTITUTIONAL ENVIRONMENT

Rationale: *The purpose of this section is to present in a synthetic form all the relevant background information that will allow to understand the context in which the CA activities have been implemented. It is vital for the sake of drawing comparisons among case studies. Most of the corresponding information should come from secondary sources such as previous reports, geographic sources and existing databases maintained at the regional (district offices), national (MoA, national research institutions) or international level (FAO)*

Examples of questions:

I.1. Main features of the agro-ecological zones (AEZ) under which the case study area falls (climate, vegetation, soil, topography, etc.)? (If possible, give name and number of the AEZ according to FAO system)
I.2. Have any changes occurred in the area's relevant climatic conditions in recent years and how have the farmers reacted to them?
I.3. What are the key relevant geographical patterns in the region (economic activities, urban centres, basic infrastructure, markets and communication) ?
I.4. What are the most relevant socio-economic and socio-cultural characteristics of families and communities?
I.7. Description of existing farming systems
I.9. Labour-related issues at the household and community levels
I.10. Degradation of the Environment / Natural resource base
   a. Are there indications that soil and natural resources degradation is occurring within the context of existing farming practices

II BRIEF SYNTHESIS OF CA-RELATED WORK IN THE REGION

Rationale*: The purpose of this section is to present the history of CA work in the region, tracing back any project, program or effort that pursued a CA-related agenda. It may well be that past efforts were not necessarily well coordinated or did not encompass a large range of CA activities. For example, research trials may have started on-station without any on-farm or extension component. Or CA extension work can have started in some communities without formal government support. What is important is to identify the origin and impact of previous activities, to provide a historical context to present-day CA activities.*

Examples of questions

II.1. When did the first CA activities start in the region? Which aspects of the CA agenda were initially tackled? Who conducted these activities?
II.3. Has the region benefited directly from CA efforts, results undertaken in different regions within or outside the country? If yes, give details
II.4. What are the main lessons and results from previous CA projects and programs, which operated in the region, that have been incorporated in the on-going CA program?

III AN OVERVIEW OF THE CA ADAPTATION & DIFFUSION PROCESS

Rationale*: There are many ways CA programs and projects can operate, depending on the specific stakeholders involved, the choice of approaches and methodologies, the funding sources, etc. The purpose of this section then is to describe and understand the main features of the CA adaptation and diffusion process that shape the way CA activities and technologies are implemented nowadays. While it may be difficult to go many years back, it is necessary to analyze in this section not only the current CA project or program, but also the most*

significant CA activities which were implemented in the recent past, if and when their influence is determinant to understand what is going on presently.

Examples of questions:

III.1. Indicate period covered by the subsequent analysis

III.2. Project / programme specification (name, address, if possible organigram showing key players / actors and components of the project)

III.3. When was the current project initiated? Starting year, start and end of the various phases the current project has been through, planned end date of current project

III.4. Origin of funding sources for the current project

III.6. Stakeholder involvement

b. Who has conducted the various adaptation & dissemination tasks / activities? What has been the specific role played by farmers in this process?

III.13. Gender issues

a. How have the different needs of women and men been taken into account in the design and implementation of these activities?

b. Were there differences between the participation of men and women?

III.17. Training

c. What form of training was provided for farmers? (Categories: on-the-job, farm visits, demonstration areas, public meetings, courses, other

III.18. Extension & Technical assistance to farmers

a. Through whom is the extension being carried out? (categories: farmer-to-farmer extension, project's own extension structure and agents, government's existing extension system, non-governmental agencies, other)

III.22. Access to CA-related inputs, services, and subsidies

III.29. Overall, what have been the main problems and successes encountered during the CA adaptation and adoption process?

IV DESCRIPTION OF CA TECHNOLOGIES & SYSTEMS

Rationale: *The purpose of this section is to describe the major CA technologies or systems that have been introduced and promoted in the region, without attempting to be exhaustive (only major systems should be described), and without assessing their actual impact (this will be done in the next section). Only those specific CA technologies that are already being recommended for use by farmers need to be detailed, both for the initial year in which they are introduced and for subsequent years. They will need to be presented in contrast to the current farmers' practices they are intended to substitute for. Those CA technologies still under development (through on-station or on-farm experimentation) will only be mentioned. Finally, they will need to be described specifically for each type of rotation / main crop for which.*

Examples of questions:

IV1.1. For which main crops have CA technologies been made available? For which crops are there still missing?

IV1.3. When are farmers expected to start reaping the first benefits from applying the recommended CA technologies?

IV1.4. Indicate any competing uses for the biomass needed for providing soil cover

IV1.6. Do the recommended CA technologies incorporate indigenous knowledge practices, norms and beliefs?

IV.2 Questions for each major CA technology or system

IV2.3 Which specific problem is this CA technology addressing?

IV2.4 Where did this technology come from originally? By whom was it designed into its present form? When did the promotion of this technology start in the region?

IV2.15 How are farmers supposed to manage the cover (mechanically, chemically, biologically, etc) ? How is the cover being protected from losses through burning, grazing, or any other extraction mechanism?

IV2.22 State important benefits and constraints with this CA technology from the view point of the project promoting it?

V CA IMPACT AND ADOPTION

Rationale*: After having described the CA adaptation and adoption process, and the key CA technologies, we will now focus our attention to the actual impact the key CA technologies that have been promoted are having in agronomic and environmental terms, as well as in economic and social terms. We will also assess the levels of and trends in adoption of the various CA technologies.*

Examples of questions:

V1. Agronomic & environmental impact of specific CA technologies at the field level

V1.3 What impact (positive or negative) have the farmers who used this CA technology observed on the following aspects:
   a. Crop grain yield compared to existing systems
   b. Forage yield or quality
   c. Other increases in output (wood, etc.)
   d. Crop yield stability over the years (if applicable),
   e. Planting calendars compared to existing systems
   f. Weeding calendars

V1.4 What changes did farmers observe on soil fertility, erosion (if applicable)

V1.12 Describe how effective CA adoption has been in (i) reducing workloads, and (iii) who have been the main beneficiaries

V1.13 Main benefits associated with the use of this CA system

V1.14 Main drawbacks associated with use of this CA system

V2. Socio-economic impact and evaluation of process aspects

V2.1 Who makes the decisions on the implementation of the CA technology at the household level? (categories:men/ women, young/ old, etc.)

V2.3 Are data available on the economic returns resulting from the use of CA technologies

V2.5 Have the adopted CA practices helped families to cope better with adverse situations?

V2.6 Have communities developed or reformulated certain by-laws to favor CA use? Which ones? Why? How efficient are the new by-laws in reaching their stated objectives?

V2.8 Have the introduction and adoption of CA changed the relationships among farmers within their community or among neighboring ones? What has caused the changes, if any?

V2.16 Have some of the CA technologies "spontaneously" been adopted by some farmers? Which ones? Why are they met success?

V2.28 How are those who adopted CA practices viewed in their community / village and to what extent are they heard in the existing local hierarchies, politics, and power relations?

V2.31 To what extent do CA practices take relevant health problems into consideration (e.g. HIV/AIDS, malaria, etc.)?

V3. Adoption trends

V3.1 Approximately how many farmers are using the system today in the region? Since when?

V3.2 What has been the trend in adoption or use over the past two decades or so?

VI GAPS, CHALLENGES AND FUTURE PERSPECTIVES OF CA WORK IN THE REGION

Rationale : *We have now to make a qualitative balance of the status of the CA technologies and of the CA adaptation and adoption process in the region, trying to speculute about how things could changed or be improved in the future*

Examples of questions:

VI.1 What are the main challenges CA is facing in the region?

VI.2 What are the main reasons for the observed impacts (or lack of impact) (internal and external factors)? What are the main challenges?

VI.10 Are the farmers who use these CA systems confronted by problems which require research? If yes, what research themes need to be given attention?

VI.12 Looking towards the future
   a. What is the future plans in scaling up?
   b. If the project was being started anew, would you propose major changes, and which ones?
   c. Will farmers be able to continue CA adaptation and adoption without external support?

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