A FARMING SYSTEM ANALYSIS

OF MVUMI DIVISION,

DODOMA REGION,

TANZANIA

A case study on intensifying agriculture in semi-arid Africa

Mvumi Rural Training Centre

Communication Bulletin

number 1, 1994

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Foreword

The Mvumi Rural Training Centre was established in 1989 by the Diocese of Central Tanganyika of the Anglican church. It is sponsored by two Dutch NGO's: ICCO (= Interchurch Coordination Committee for development projects) gives financial support and SNV (= Netherlands development organisation) supplies manpower in the form of an agricultural advisor. The mandate area of the centre is the Mvumi division in Dodoma rural district.

The MRTC is working closely together with the Government of Tanzania (GOT) in the field of agricultural development. Two staff members are seconded from the GOT and the implementation of the programs is done in cooperation with the Village Extension Workers (VEW's) of the GOT.

The aim of the centre is to increase the economic and nutritional status of the people of Mvumi division via a more productive and more sustainable farming system. In order to be able to do this, research is needed as little knowledge about the farming system in Mvumi is ready available. This research is done and will be done in the form of RRA's, farm management survey's, on-farm- and on-station trials. As much as possible this is done in cooperation with people form research institutes. To make the results of the research available to others they are published in the Communication Bulletins of the MRTC. As all good communication is two way communication everybody is invited to send their remarks to the MRTC.

The aim of the communication bulletins is to supply policy makers with reliable data analyzed in the context of the daily lives of the farmers, so that agricultural planning can be improved. The target group of the bulletins are policy makers (in the extension service, NGO's, research institutes or universities) active in the field of agriculture or natural resource management.

Everybody may feel free to quote these papers, but it would be appreciated when a copy of the paper in which this is done is sent to the MRTC.:

M.R.T.C.
P.O.Box 38
Mvumi, Dodoma
Tanzania

More copies of this bulletin can be obtained via the same address. They cost 5 US dollars or its equivalent in Tsh., made payable to account nr. 3074/26 of the DCT-Mvumi of Mazengo branch in Dodoma of the National Bank of Commerce in Tanzania.

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Finally the team members of the RRA on the position of women in May 1993 should be mentioned: Mrs. M. Mhaville (Extensionist, DOVAP and teamleader), Mr. P. Mnyangulu (MRTC coordinator), Mrs. N. Ndembeka (MRTC, Comm. dev. department), Mrs. Grace Nathonsigaye (CHP), Mr. Oscar Ngomaa (CHP), Mrs. I. Scholte (CHP), Mr. Muro (DLUMP), Mrs. Stella (DLUMP, Min. of Comm. Dev.), Mrs. V. Sweti, Mrs. M. Nghalo (farmer Ilolo), Mrs. Rose (farmer Nghahelezi), Mr. E. Ulomi and Mr. Kambona.

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Lastly my wife Ineke Scholte should be mentioned for supporting me during the long process of writing (often outside normal working hours) and for critically reviewing some of the drafts.

Despite all this assistance of course only the author is to be blamed for any mistake.

Mvumi 13-6-1994
G. Holtland

1 INTRODUCTION

The present study was started in 1991 and was meant to give a short overview of the findings of the RRA done by the MRTC in April of that year. However as other jobs always seemed more pressing it did not get finalised quickly and as new information was coming in regularly it had the status of a draft for 3 years. Now as it is finished it is longer than originally planned. For issues like the destocking, zero-grazing and agroforestry separate communication bulletins were planned but time was too short to realise this, so the most important aspects of these issues are dealt with here.

The basic sources for this study are:
- the Rapid Rural Appraisal by the MRTC in April 1991
- the evaluations of the food crop extension programs in the area in 1992 and 1993 by MRTC, District Crop Officer, Global 2000 coordinator, CHP, HADO and farmers;
- the farm management survey of 78 zero-grazing farmers in March 1993 which was part of the evaluation of the livestock program of the MRTC;
- the RRA on the position of women by MRTC, CHP and DLUMP in 1993.

Other sources are discussions with farmers and extension workers, observation in the villages, trials done by MRTC (on station and on farm) and literature. Often the data on Mvumi are compared and supplemented with data of a farm management survey which was done in 1981-83 in different farming system in Dodoma region. This survey was part of a planning cycle for the Integrated Development Plan for Dodoma (AHT, 1984). Another survey done in the same years by SPWP gives a lot of economic data (v. Dijk, 1985). Next to this the excellent study of C. Christiansson on soil erosion in semi-arid Tanzania must be mentioned. It gives a lot of data and background information in the interesting context of the history of the area.

Non of the sources can be said to be the most important, it is the combination of sources which makes the picture complete. It is the continuous counterchecking of facts during the regular extension visits in the villages which makes the information reliable.

Some people will find too many details in this paper and others will find that too often model calculations are used which one might consider too theoretical. The reason is that a lot of data are not available and it is the conviction of the author that the resulting gaps are better filled with 'common knowledge' than left open. It makes it possible to draw at least some tentative conclusions and at the same time it is meant to challenge the readers to come with better data.

Unless stated otherwise, calculations are based on 1991/92 prices. The exchange rate was about 230 Tsh. per US dollar by that time. It is one of the striking facts that by 1994 this exchange rate has more than doubled (to 520 Tsh/dollar) while the prices of local products can be estimated to have increased by only 50%.

Chapter 2 gives some background information on the area. In chapter 3 this is followed by information on the cultural and socio-economic environment of the farmers in Mvumi. Chapter 4 deals with the physical environment: climate, soils and vegetation. Chapter 5 concentrates on land use issues. Chapter 6 gives the details of the cropping system, chapter 7 of the livestock system and chapter 8 of the tree component of the farming system. Chapter 9 gives a summary of the major constraints in the farming system as described in the previous chapters. In chapter 10 the possible innovations which could be tried out in Mvumi are evaluated and a decision matrix is made to select the most promising ones.

2 BACKGROUND INFORMATION

2.1 Introduction

Mvumi division is part of the Dodoma rural district. It is situated about 40 km south-east from Dodoma town, the capital of Tanzania which lies on 6.2 °S and 36°E. Within the division 6 wards and 13 villages are found. The map shows how these are situated.

Figure 1 Map of Mvumi division

2.2 Population

Nearly all inhabitants are Wagogo, a tribe of cultivating pastoralists: economically they have to rely on crop production but on the level of ideology and culture cows are more important (Rigby, 1968: see also 4.1).

Mvumi has already for over hundred years a high population density. It has relatively fertile soils, it is rather flat and water is relatively easily available. Moreover in the nineteenth century the population increased as a result of fights between the Wagogo and the Wahehe from southern Tanzania. The Wahehe were stronger and many Wagogo fled to Mvumi which was near enough to Dodoma (the centre of Ugogo) to feel protected. Meyer wrote in 1909: "In the central range of hills the settlements are located so closely to each other that they form villages. In the most fertile areas, Handali, Ndebwe, Mvumi and others toward the west the villages line up mile after mile each with 1,000 - 5,000 inhabitants." (cited from Christiansson, 1981).

In 1988 a national census was held and at that time 48,399 people were living in Mvumi division. The national population growth in the period 1978-1988 was 2.8%, in Dodoma region it was 2.4%. If the growth has been 2.4% in the last years the population of Mvumi is over 55.000 in 1994.

The total area of the division is 730 km^2, giving a population density of 76 inh/km^2. Mvumi Mission has the highest density: 173 inh/km^2, partly because of the hospital. Next is Ngahelezi: 128 inh/km^2 with only agricultural activities. There is a large difference between the more overpopulated western part of the division (117 inh/km^2) and the less populated eastern part (50 inh./km^2).

Nationwide the population density is ca. 30, in Dodoma region it is 33 inh./-km^2 and Dodoma rural district has 27 inh/km^2. According to FAO (1982) the actual average population density in 1975 in similar areas Africa was 13 inh/km^2; in 1994 this will be 24 inh/km^2 (growth rate of 3% p.a.). The Worldbank (1984) cites an actual population density of 23 inh/km^2 in the Sahelo-Sudan zone in West Africa for the beginning of the 1980's, which comes to 32 inh/km^2 now. Model studies on the sustainable population density show that in the zone with 500-900 mm rainfall between 10 and 25 inh/ km^2 can be supported by the natural environment using intermediate levels of inputs. Christiansson (1981) estimates that the max. carrying capacity for pure subsistence agro-pastoralism in Ugogo is 37 inh/km^2.

Compared to all this the Mvumi division has a very high population density which is beyond its carrying capacity. In chapter 5 this is further explained, based on the available amount of land per capita and the productivity of the land.

2.3 Migration

Migrant labour has a long history in Ugogo. The census of 1957 showed an out-migration of 14% for economic active men from Ugogo, mostly young men who went to work elsewhere for one or two years. After returning home they remained there (Rigby, 1968). Data from Mundemu (Dodoma rural district) in 1983/84 show a population density of 23 inh/km^2 and an outmigration of men of

19% (AHT, 1984). The SPWP survey in 8 villages in Dodoma Urban district in 1982/83 showed a population density of 38 inh/km² and an outmigration of 20%. In 1988 Dodoma rural district (without Mvumi) had an outmigration of economic active men of 24% while the population density was 27 inh/km². In 1988 in Mvumi the population density was 66 inh/km² while the outmigration of economic active men was 38%. This shows that with increasing population pressure in Ugogo outmigration is increasing. In Mvumi the population density is about double the average of surrounding areas and the outmigration is about 50% higher than elsewhere.

Most of the migrating young men go to Dar es Salaam, f.e. to work in the butcheries owned by people from Mvumi. Others stay in Dodoma or in towns like Arusha, Iringa and Moshi. They often work in restaurants, in grains mills etc.. Many sneak away without informing their family. The majority hardly brings any money back home.

Next to this more permanent migration, many men leave Mvumi for temporary jobs in the dry season, or even during the rainy seasons if the harvest has been very poor. They go for a few weeks, come back with some food and after nearly finishing this, they go again. They usually work as daily labourers in areas like Mpwapwa, Kilosa and Morogoro. These are the same areas where the Wagogo used to fled in the past when there was no assistance from the government in periods of hunger. Also working in the tobacco areas of Tabora is a normal practice. The income of this group is more important for Mvumi. Due to the worsening terms of trade for local products in the last couple of years this type of migration is increasing.

2.4 Social services: education and health

Mvumi Mission is known for its good education in the past, based on missionaries schools. It took the missionaries a long time to convince the Wagogo to bring their children to school. Finally the young 'mtemi' Mazengo (see 3.3) encouraged children to study. This early education resulted in some high placed persons from Mvumi, among them the present prime minister of Tanzania. The irony wants that Mazengo did not bring his own sons to school, so they are now bypassed, both in social and in economic sense, by the boys of the poor families who were educated.

Nowadays most people are very much convinced of the need of education, but the educational situation has turned bad. Most schools are in a bad state, many children are taught under trees and teaching materials are hardly available. This demotivates both the children and the teacher. Also the low salaries of the teachers is a problem as well as their own low educational background. Many teachers are non-Wagogo and for them living in the poor villages is difficult.

Although many children are going to school they learn very little there. Most of them only reach a status whereby they master the basics of reading and writing but that is about all. Very few go to secondary schools; from the whole division usually between 10 and 20 per year, representing about 1% of all pupils. Of the 15 going to secondary schools again half might be of non-Wagogo parents. The 1% is low compared to the national average of 5%. That they can enter anyway is caused by the GOT who gives all districts a certain number of places in secondary schools. This gives pupils in poorer areas still a chance. In practice however many of those going to secondary school drop out because of their poor basic education.

In 1994 the Diocese of Central Tanganyika (re-)opened a secondary school in Mvumi Mission. The GOT is building another one in Handali.

Figure 2 The vaccination coverage is still good

In general the health situation in Mvumi is also bad. Few reliable figures exist, but estimates (of the Community health Program of the Mvumi hospital) of the under five death rate, based on interviews in 1982 and 1987, are about 13%. In the first 3 months even 28% of the babies die. The most important death causes in the children ward of Mvumi hospital in 1992 were: malaria, malaria in combination with anaemia, pneumonia, malnutrition and meningitis. Many diseases are present due to poor hygiene, poor weaning practices, lack of medical facilities and malnutrition. Over 50% of the children are malnourished, of which nearly 7% are severe cases (all data from the Mvumi Community Health Program). Data from the Dodoma Integrated Rural Development Project working in a less densely populated area west of Dodoma indicate that the severe malnutrition is less there: between 0.5 and 3 percent.

In Mvumi Mission a hospital of the Diocese of Central Tanganyika offers good facilities. Many people, however, can not afford to go there: it is becoming too expensive and transport is a problem. There is also one Health Centre and two Dispensaries where people can be admitted. These do not have much facilities and drugs. Most other villages are in the community based Community Health Programme of the DCT-Mvumi Hospital.

Within the health service the same problems are encountered as in the educational sector: low salaries, low educational background, no working materials and funds, many non-Wagogo who do not like the area. As the GOT now allows private clinics a lot of personnel leaves the government (or church) hospital for higher wages elsewhere. Despite this the coverage of vaccinations and the attendance of MCH clinics it still good.

2.5 Water

Both the quantity and the quality of water in Mvumi is inadequate. Many people walk long distances (up to 6 km) to fetch water in (shallow) holes in sandy river beds. At the end of the dry season 50 Tsh is paid for a bucket of water (20 l.). The ARDHI survey of 1988 found that one third of the households use only one bucket of water per day. Another third uses only two buckets. This shortage gives severe hygiene problems, as well as a draw back to agricultural activities like vegetable growing, tree nurseries and zero-grazing. Most of the water is very salt and very hard (i.e. it has a very high Ca content). It is too salt to drink, sometimes even too salt to wash cloths with.

In the past many boreholes were established and most villages have one at the moment. However only a few are working: in Mvumi Mission and in Mvumi Makulu (both on electricity) and also these break down regularly. In the dry season of 1992 two more boreholes started working: in Ilolo as a result of own local initiative and in Mzula where WATERAID assisted the villagers to get a new pump. People contribute money for diesel, either via a general contribution (Ilolo) or via paying for the water (5 Tsh./bucket, Mzula). All other machines are broken down permanent or people refuse to pay for the necessary fuel. In the past livestock owners used to pay for this, but after destocking this source of money dried up. The histories of the pumps are usually sad ones of mismanagement and stolen spare parts. This caused a lot of mistrust in the villages.

Figure 3 Some walk up to 6 km

Next to the diesel driven pumps several handpumps can be found, among others in M. Mission, M. Makulu, Idifu and Muungano. They are brought by agencies like HADO and WATERAID and they also break down frequently.

2.6 Roads, transport and communications

Compared to many other areas in Dodoma and Tanzania, the roads in Mvumi are reasonable good. The main road from Dodoma passing Mvumi Makulu, Mvumi Mission, Ndebwe and Handali (see fig. 1) and going to Kikombo and Buigiri is passable the whole year. Also the smaller feeder roads are not bad. Nearly all villages can be reached the whole year.

Although the roads are good there are not enough means of transport. For the whole division there are about 6 lorries/cars. Most go up and down from Mvumi Mission to Dodoma either via Buigiri or via Mvumi Makulu. The rest of the division relies also on these cars. People walk at night to the main road to catch them in the morning. When someone is ill in the village it is difficult to find transport to the hospital or to health centres. Most cars are owned by one family in Mvumi Mission.

Transport within the villages is a problem. There are very few means to transport water, crops, firewood, building materials, etc. Only a few hand carts are available.

2.7 Religion

Most people belong to the Anglican church, which has parishes in all villages of the division. Other denominations are Roman Catholic and Assemblies. There are a few muslims. Traditional diviners are still important in daily live. Specially when it comes to rain making rituals or in cases of witchcraft.

The Anglican church is an important social actor with many youth and women groups and several projects. During severe food shortage it caters for most of the food relief.

3 THE SOCIO-ECONOMIC AND CULTURAL ENVIRONMENT

3.1 Historical context

The name Wagogo is of fairly recent origin (last century), but this does not mean that the cultural identity of the Wagogo is young. According to Rigby (1968) the Wagogo have been living in their present area for several hundred years. In general it is thought that the Wagogo came in their present area of residence in the second half of the eighteenth century.

In the first two hundred years of residence in the area they were forced to move every now and then because of attacks from Masai in the north and Wahehe in the south, severe outbreaks of epidemic diseases for humans and cattle and the recurrent droughts with the resulting famine. These movements over longer distances were further complicated by more 'regular' movements of households in search of new virgin land for crop production and grazing.

Before the colonial period started at the end of the nineteenth century the Wagogo were already exposed to the outside world by the many caravans passing through the area on their way to Tabora (for iron, slaves, etc). The large quantities of grain which the Wagogo sold to these caravans lead to the first over-exploitation of the available resources and to erosion along the caravan routes. This engraved the periodic famines in the area and forced many families to move away from the caravan routes.

At the end of the nineteenth century rinderpest severely hit the herd of the Wagogo, and possibly it never recovered completely from it. In 1918/19 a severe drought and an epidemic influenza decimated both the human and the cattle population. In 1925 it was estimated that about 30,000 people died of hunger or influenza in 1919. This must have been a quarter of the population. This famine (known as 'Mutunya') is considered to be the last great famine by the people in Mvumi. Afterwards they got used to food relief from the government and other agencies.

3.2 Cultural context

As mentioned before the Wagogo can best be described as 'cultivating pastoralists': economically they have to rely on crop production but on the level of ideology and culture cows are more important (Rigby, 1968). The crop production was the major reason for the frequent moving of Wagogo households. Within the lifespan of one man a households used to move several times in response to the need for new fields as the fields around the old homestead lost their initial fertility. Rigby (1968) showed that 70% of the homesteads in his study area in 1962 were established by the present generation. Usually people moved within a few kilometres, but some moved several tens of kilometres

By moving a head of a homestead had to establish new contacts with other homesteads in the neighbourhood. Living completely independent as a homestead was not possible for security reasons and for the necessity to mobilise a lot of labour during peak periods of crop production. A major way of establishing new ties was marriage.

Over time the Wagogo culture developed as a respons to the frequent moving: the basic social unit became the homestead (*'kaya'*). This is headed by a male who lives together with his wife(s) and some other relatives (mostly brothers with their wives). The head of the homestead is responsible for the ritual wellbeing of his people, in cooperation with the ritual leader (*'mtemi'*) of the area. Every woman and her children forms an independent unit (*'nyumba' or 'mlango'*) within the homestead. Women are responsible for the ritual fertility of the fields (via medicines obtained from the 'mtemi') and they are the 'owners' of the yield (see also 3.4). Livestock production and fertility (= ritual wellbeing) is in the hand of men. They are the only ones who can inherit cattle (only in exceptional cases women can also) and can decide on its use. Women again are responsible for the milking and the use of the milk. For Wagogo crop production is vital but land is not as it can not be taken with the family when it moves. As a result nobody owns land, but the usufruct of a field can be possessed and this 'ownership' is extended into the first 2 years of the fallow period.

Livestock is the principle inherited property of a family: it can be taken anywhere and is easy divisible. There are no strict rules on how livestock is divided between the different heirs. The share a son gets depends not only on age but also on his social abilities and his leadership qualities. As sons need many cows to be able to marry this often leads to conflicts between brothers or even between father and sons. The distrust within families explains that cows giving to others in trusteeship (see 7.1.5) are not often given to family members, as they might not give them back. Possibly as a result of this it seems that Wagogo easily betray each other when it comes to livestock ownership, specially within their own family. Rigby (1968) describes some interesting cases of sons who managed to get a bigger share than normally might be expected by clever social manoeuvres.

Marrying involved large number of cattle; in general the bride-wealth exceeded the average herd size and it was custom that a bride-wealth could not come just from one herd. So anybody who wants to marry had to ask assistance from others like brothers and uncles to get the bride-wealth ready. The elder brother of his mother played a special role and would also give a (small) part of the bride-wealth. If a daughter was married out he would also receive a (small) part of the bride-wealth for her. This all lead to a complex system of livestock-ownership whereby most of the time an animal is not completely owned by somebody but only its usufruct, and many people can have a kind of right/claim on an animal, f.e. in case they want to marry. In this way also women have claims on animals on behalf of their sons.

In general the Wagogo do not fit well into the general picture of African cultures in which the extended family is the core of all thinking and handling. Rigby (1968) concludes that "the factor descent does not produce cooperating (or corporate) groups beyond the 'sons of one man'. But the affinal and resulting cognatic relationships set up in each generation and between proximate generations do provide strong localized bonds upon which cooperation in all spheres, including the economic and ritual, is based. The network of kin relationship involved in such cooperation is in each case an ego-oriented one." (Rigby, 1968).

In simple words: due to the frequent moving and the complex system of livestock ownership Wagogo cooperate more easily with friends and neighbours than within their extended family. This observation is readily agreed upon by Wagogo in Mvumi these days.

Figure 4 A typical Gogo homestead

3.3 Political context

Pre-colonial situation: decentralised political structure

Politically the Wagogo have always been very weak. The major reason is the very diverse cultural background as many clans (claim to) come from different areas. Secondly the frequent moving lead to strong basic units (homesteads) with a loose structure of neighbourhoods/villages and clans above it. No permanent centre of power was established. Even the family ties are fairly loose and every son will after some time break with his father and start his own independent homestead; partly because of land scarcity and partly to establish his own right over his own herd.

So traditionally the Wagogo have a very decentralized political structure. Most decisions were taken on household level or on the level of homestead groups. Above household level ritual areas are distinguished of which there are possibly over 100 in the whole of Ugogo (Rigby, 1968). A ritual area has a ritual leader ('mtemi') who brings 'new fire' and protective medicines for the crops every year. His homestead was a save heaven for all criminals. His power does not extend into political affairs according to Rigby (1968), but he does act as a judge and as a spokesmen for his people. The 'mtemi' was assisted by his 'mpembamoto' who again were assisted by the 'mzenga-tumbi' who's position can be compared with a village chairman of these days. His assistance were called 'wanyahala', who's jobs was more or less the same as the present 'mgambo' or 'sungu-sungu'. Next to these other influential people were rainmakers, traditional healers and the people in charge of a 'Luwindo' (= temporally closed grazing areas). All these positions were not automatically inherited by the sons, they could be passed on to others in or outside the family if the need arouse (due to inability of the sons).

Colonial times: indirect rule via strong chiefs

The above described very loose political-jural structure was difficult to cope with for the British colonial administration. In 1926 they installed the system of indirect rule for which they created government chiefdoms and an administrative hierarchy based upon them. They managed to make some watemi to powerful chiefs and political leaders of all Wagogo. The most important one was Chief Mazengo who lived in Mvumi Makulu. He was the first 'mtemi' to be baptised and had good relations with the missionaries. He managed to get great power in whole Ugogo, although his influence was biggest around Mvumi.

Independence: the abolishment of chiefdom

Soon after independence in 1962 the government of Tanzania abolished the system of chiefdom. For the Wagogo this meant that Mazengo and his assistants had no official role to play anymore, but based on his reputation and as a personal friend of Nyerere he staid influential till his death in 1969. After his death the traditional leaders in the form of real 'Watemi' and clan elders ('Wanyahala'/'Wandewa') regained their traditional role. This could not bring them any political power as first of all they did not have this in the past and secondly the indirect rule was succeeded by direct rule: the GOT appointed area-commissioners and judges who were the new political and jural power. So although some traditional leaders and some decision structures of the Wagogo are still somehow functioning they have little influence. They only solve minor conflicts and internal family problems. For major problems they usually refer to government courts.

An interesting case occurred in 1993 when somebody claimed to have stopped the rains and indeed it did not rain. As people feared for their harvest they started to destroy the house and fields of the person involved. The government failed to handle the case and asked the 'mtemi' (a grandson of Mazengo) to help. Indeed he managed to handle the emotions.

The enforced villagisation in the seventies and CCM rule

As in many other parts of Dodoma region (specially Dodoma rural district) the villagisation was radically and forcefully implemented in Mvumi. About 40% of the population moved into the villages between 1971 and 1974. In some villages 70% of the population came in 1972-1973. It was no success: people staid too far from their fields. This reduced the productivity of agriculture, as did the compulsory cultivation of the village ('Ujamaa') fields of which the village government took half the yield. At the same time it proved that the government of Tanzania was not able to provide the social services which it had promised to the villages: schools, health centres, water, etc.. It took a long time before the failure of Ujamaa could be admitted, but these days people are slowly returning to their former homesteads.

Ujamaa had a profound effect on the leadership of the villages. People who used to live together in a small village (homestead groups) came to live in one part (a 'mtaa') of an Ujamaa-village. Many times this resulted in a marked social difference between the 'mtaa's' and they usually have a higher social coherence than the village as a whole. Those who came later staid far from the centre with the market, the school, the CCM buildings etc. They hardly gained any power in the village, both politically and economically. Often they just try to avoid contact with party and government (workers) and all they want is going back to their old homes. The problem in Mvumi is worse than elsewhere as not only the Ujamaa laws do not allow this but also HADO prohibits the clearing of new fields.

Another problem is the misuse by Ujamaa-village leaders of assets which the villages were given (often as a loan) by the GOT in the 1970's and 1980's (lorries, grainmills, waterpumps). As a result of these problems people started to turn their back to politics and politicians. They elected weak leaders in order to reduce the impact of the GOT on their lives.

The GOT keeps the village and ward leaders under pressure to follow GOT policies. In response these leaders developed a 'hard line policy' towards their own population and farmers are just seen as stubborn individuals who refuse to pay their tax. Not only tax but also 'voluntary contributions' for development projects (health centres, schools) or visits of high officials are just squeezed out of the population. In general the much debated books of Hydn (1980 and 1983) give a good analysis of how these mechanisms work.

Conclusion

So as a result of:
- the traditional fragmented political structure of the Wagogo;
- the creation of more powerful chiefs by the colonial rulers;
- the consequent abolishment of chiefdom again after independence;
- and the failure of the Ujamaa-CCM politics

both the traditional and the official leaders are very weak and have no authority at all. In practise there is no village leadership, few village meetings (with few participants) and no village policy. Everything is decided on an ad-hoc base by the chairman and/or the village secretary and/or the ward secretary. Needless to say that this ends up in absurd decisions and misuse of funds which again engraves all problems.

Tanzania recently decided to embark on a multi-party-system. However this did not yet give much changes on village level. Until now it only added confusion of who is responsible for what, as there are many public offices to be fulfilled. In one village up to 8 people can be stationed who all need part of the power: the ward chairman of the GOT, the same for the CCM; ward secretary of the GOT, same for CCM; the village chairman of the GOT, same for the CCM; village secretary for the GOT, same for CCM. Until now the same people of the past go on with their former activities, and it depends on their personality what their actual task/ work is. Specially for the CCM leaders it is unclear what their role is. What power has a CCM secretary in a multi-party system? What is the role of the CCM chairman of the ward? In theory this is clear, but in practice not always.

3.4 Position of women

As in many African societies a woman and her children form the basic social unit (in Cigogo called 'nyumba') which is independent vis-a-vis the larger household ('kaya') which can consist of several 'nyumba's', other relatives and adopted members ('ndugu's'). The position of the women in this system is dualistic. On one side they are economically independent with their 'nyumba', on the other side they have no official right of ownership over resources like land and livestock.

To get a picture of the traditional independent position of women Rigby is cited here (Rigby 1968: 172, 174):

> "A woman and her children form an almost completely independent economic domestic group for the production, storing, distribution and consumption of food."

> "For the principle inheritable property, livestock, a certain part of the homestead herd is allocated to every 'nyumba' as soon as children

are born. These livestock are utilized exclusively by the wife of that nyumba and her children..... ."

"A husband can not use the grains from any wife's granary without her permission, just as he must consult her and her adolescent or adult children over the use of livestock allocated to their nyumba"

In general this picture is too simple and too optimistic. As mentioned the other side of the picture is that Wagogo women are the property of their husband who paid a bride-wealth for her. More precisely, one family buys the working power of a woman from the other family. Some elder people in Mvumi said that in the past women were considered slaves ('watumi'). Up till today women feel more secure with their own family than with the family of their husbands. A large bride-wealth (like in the past) leads to a weak position of a woman as she can hardly return to her father as he would not be able (or willing) to give the bride-wealth back.

Nowadays most fields are family fields and the husband and the wife are together responsible for the food production. Next to this both can have their own fields. Also in these fields they can assist each other, but after the harvest the yields are kept separate as described by Rigby. In principle a woman can decide upon the use of the harvest from her field and mostly she uses it for household purposes. However the husband can overrule her decision and can demand the harvest/money. This is not considered good behaviour (as reflected by Rigby's statements), but happens often, the argument being that the man paid the bride-wealth. In cases of food shortage men go to work for food elsewhere while the women stay behind with the children. In case of surplus this will usually be generated on fields officially owned by the husband, so he takes the benefits of it.

Traditionally women do the milking and they have the right over all the milk, although this right can again be overruled by their husband. This is also the case with all income generating projects which women can undertake: brewing beer, making salt, making clay pots and making mats. The women usually get the income, but if the man decides he needs the money more urgently the women can not do much except giving it. In those cases the man usually claims that the woman used the resources of the household for the income generating projects. F.e. when a woman makes beer she usually takes the grains of the family. If this is not the case his basic argument returns that the wife is his property as he paid for her.

A few traditional men refuse their wives even to undertake any income generating activity, they want her to work only for them. Also some traditional believes forbid income generating activities for women, f.e. the production of salt in the wet season as it would stop the rains or the cultivation of some marketable vegetables (like tomatoes) as the presence of women (specially in their monthly period) would make the fruits to rot.

The workload of women in Mvumi is much higher than of men. Traditionally clearing new fields and threshing are men's jobs and planting and winnowing women's jobs. Nowadays people claim that men and women are just working together on the land. Indeed there is no strict division of labour: it is not forbidden for any of the sexes to do a particular job. Still men do most of the clearing and digging and women do more of the burning, weeding and harvesting. Threshing and winnowing is done simultaneously whereby the winnowing is only done by women, which leaves (most of) the threshing to the men.

Next to these agriculture tasks women have many other duties: fetching water, child care, food processing and preparation and collecting firewood.

Since independence many women groups were formed by churches and UWT (Umajo ya Wanawake ya Taifa, the women mass movement of the CCM). Most of these suffer from the following weaknesses:
- no clear aim;
- no clear membership criteria;
- too many members;
- lack of expertise to run economic activities;
- members don't profit individually: profits are for a common aim;
- weak leadership.

Figure 5 Only cultural groups and choirs are permanent

During the RRA on the position of women in 1993 it was found that few traditional women groups existed. Only cultural groups and church choirs are permanent groups. Even the few beer making groups are usually on an ad-hoc base. Most of the women are bound to their family chores, specially as the number of children is very high. Traditionally a child spacing strategy was used as the men slept separately from their wives for a long period after her delivery. Now that custom has disappeared, causing repetitive pregnancy and malnutrition among small children as a breastfeeding child is immediately (and suddenly) weaned when a mother is pregnant again.

In general the position of women was found slightly better in the bigger villages where women had been exposed to the 'modern world'. Specially in Mvumi Makulu several female heads of households are respected members of society. One of them could only be prevented from becoming the village chairperson by some 'manoeuvres' of her opponent. In Mvumi Mission the chairperson is a woman.

In general the government institutions seem to offer better chances for the improvement of the position of women than traditional decision making structures. In the election of 1993 for the village councils 6 of the 24 seats were reserved for women. Although in the smaller villages it was sometimes difficult to find 6 women willing to participate in general it was a positive step forwards.

In total women have many tasks and few rights and it is difficult for them to do something about it. It seems that women these days are worse of than their fellow women in the beginning of the sixties (when Rigby did his research). At least their position in practise is worse than in theory. Beating of women by husbands is more the rule than the exception. If women want to take legal action against their husbands they usually accuse him of not taking care of them or the children. If they are treated too bad they can finally go back to their own family leaving behind all properties of the household, all her children (except those still breastfeeding) and usually a lot of misery. Within their own family they have the right to be given a piece of land again.

3.5 Economic activities

3.5.1 Income per capita

Most detailed information on income in Dodoma is available from the year 1982/83 in which both the RIDEP and the SPWP survey took place. Their data are quoted extensively here without mentioning all the time the sources, being AHT (1984) and van Dijk (1985). Before doing so it needs to be remarked that the data of the SPWP survey concentrate on cash income instead of the total production or total income. This distorts the comparison as it ignores subsistence oriented tasks as fetching water and firewood, growing food crops, building houses, looking after children, cooking etc. As much of this work is done by women (and by poorer families in general) their work is overlooked here. The distortion is corrected when it concerns food crop production but not for other activities as no data are available.

The RIDEP survey showed that in Mundemu the average income per capita was 62 US $: 58 for non-cattle owners and 72 for cattle owners. This includes the food produced and eaten by the family. If this is excluded non-cattle owners have 40 US $ per year/capita cash at hand and cattle owners 53 US $ (34% more).

Non-cattle owners earned 18 US $ (or 31%) in crop-production. Practically nothing of it was sold. Off-farm income provided the other 40 US $ (69%). For cattle owners crops contributed 19 US $ (or 26%) to their income while livestock sales added 37 US $ (or 52%). Another 17 US $ (23%) came from off farm activities.

In total 74% of the households had some off-farm income. Most important was beer brewing (62% of the households; over half of the total off-farm income), daily labour (40% of households) and bee keeping (32%). Smaller portion came from gift/remittances (16% of households, mostly support in the form of food as it was a bad year) and some charcoal making (1%).

Figure 6 Beer brewing: a major source of income with high returns/hour

In the same year in 10 villages in Dodoma Urban district the average cash income per capita was 133 US $ per year. This excludes the food produced and eaten by the family, so in total it must be around 150 US $ per capita. This is an effect of the vicinity of Dodoma town, as the village nearest to town had an average cash income of 171 US $ while the most remote village (bordering Mvumi division) had a cash income of 60 US $.

In the total sample crop production only raised 7 US $ or 6% of the cash income. If the food consumed by the family is also considered income then crops count for about 25 of the total income of 150 US $ (or 16%). Livestock raised

18 US $ (12% of total income). The major sources of off-farm income in this sample were: charcoal burning (19% of total income), beer brewing (17%), working in town (10%), business (7%) and skills (5%).

During the RRA in 1991 the Gross Product per Capita out of crop production in Mvumi was found to be 24 US $ in 1991, very similar to the data on Mundemu on 1982/83. In 1992 the staple crops yielded 40 US $ per capita.

Mvumi can be seen as a mixture of the two surveys of 1982/83 as its distance to Dodoma town is intermediate. The total income per capita can be roughly estimated as 100 US$/capita in 1991/92. In the western part it will be higher due to the many employees of the hospital in Mvumi Mission and the many traders and government workers in Mvumi Makulu. In the eastern part and in smaller villages it will be far less possibly only 60 US $.

Next to the height of the income also the trend is important. It is clear that the real income of the Tanzanian peasants and workers has gone down over the last decades (Slijm, 1990). Few data are available for the last few years, but it seems that as a result of the general liberalisation policy of the GOT the 'terms of trade' for local products has worsened vis a vis imported product. The price of cereals is an example: in nominal prices it rose with less than 50% since 1991/92, while the Tsh. dropped by over 100% to the US $ in the same period (from 230 to 520 Tsh./$). So for the sake of easy calculations in this report 100 US$/capita is used but in practice it is less at the moment, possibly about 80 US$ per capita for the whole division.

On average about 35% is estimated to come from crop production (staple crops, grapes, vegetables, sugarcane), 10% from livestock (the remaining local cows, chickens, zero-grazing, pigs), 25% beer brewing, 8% daily labour, 7% formal jobs, 5% business/trading and 10% miscellaneous (pottery, carpentry, blacksmithing, charcoal making, remittances from outside Mvumi, salt making etc.).

How does all this compare to the national GDP per capita of Tanzania? The estimated 100 US $ is about half of the national average. Indeed in 1988 the Gross Regional Product per capita in Dodoma region was 6.300 Tsh. or about half the national average of 12.076 Tsh. (SNV, 1991).

So the purchasing power of the population has gone down in the last few years. At the same time the liberalisation made trade more easy and a few people profited from that. This means that more consumer goods are available these days in Mvumi Mission and Mvumi Makulu, but that only few people can afford to buy them. On the other hand it is clear that also in the past the actual access to consumer goods was extremely low. Possibly the most important effect is on the social services: education and health. The access to these services and their quality have both dropped, having a negative effect both at present and for the future of the area. Whether this negative effect can be compensated in the long run by the macro-economic benefits of the liberalisation policy is impossible to predict.

3.5.2 Income distribution

An important question is how the income is distributed and how this is related to resources like land and cattle. The SPWP survey found a Gini-coefficient of 0.52 which indicates an unequal income distribution. This can be illustrated by the fact that the poorest 20% of the household earned only 1.8% of the total income. Partly this can be explained by the fact that the food produced and consumed in the household is not included in the income. If this is done, the poorest 20% of the households earn 3.5% of the total income and the gini-coefficient must be around 0.45. This is still fairly high, indicating an unequal income distribution.

What are the causes for this? How do the higher income groups obtain their income? The SPWP survey found that this differs a lot from one village to the other. In the village with the most unequal income distribution the high income group obtained more than 50% of their income from beer brewing and nearly 40% from formal jobs. In the village with the most equal income distribution the high income group got 85% of its income from charcoal making. In a third village livestock counted for 63% of the income of the high income group, in the fourth 50% came from parrot selling and in another 45% came from stone crushing. It appears that the source of income differs a lot from one village to the other. The next table can give some more insight in the overall picture.

Table 1 Relationship between income and ownership of livestock and land

	owns or earns (in perc. of total, cumulative)		
income group	income	livestock	land
poorest 20%: 1	4	4	17
2	11	13	39
3	24	34	60
4	48	53	80
richest 20%: 5	100	100	100

Source: re-calculations of data from the SPWP survey, 1985

As might be expected there is a very strong relation between income and livestock ownership, but surprisingly there is no relation between income and land ownership. This means that crop production for home consumption is practised by everybody but it is not used for generating income. Or in other words: land offers no good investment opportunities. This makes it possible that it is still more or less equally divided by all households.

3.5.3 Income per activity

Based on calculation which will be explained later (in chapter 6 and 7) and on data from Minderhoud (1993) and Holtland (1993) the income per hour worked is roughly the following for the different activities:

sugar cane:	75 Tsh./hr.
beer brewing:	75 Tsh./hr.
tomatoes:	60 Tsh./hr.
zero-grazing:	45 Tsh./hr.
field crops:	34 Tsh./hr.
livestock:	31 Tsh./hr.
salt making:	30 Tsh./hr.

In general the figures are fairly similar. In case of the livestock activities money needs to be invested for a long period so when the returns per hour were calculated an interest on the money invested of 5% was subtracted from the income. Beer brewing gives the highest income, followed by growing sugarcane and tomatoes. All three are however risky in terms of marketing, while they also draw on scarse resources like suitable land and skills. The more normal activities in crop production and livestock keeping have very low returns, less than 0.1 US $/hour. Zero-grazing with improved cows takes an intermediate position.

3.6 Input supply and marketing

The input supply structure in Mvumi is very poor. A few shops in Mvumi Mission sell basic inputs like hoes, some pesticides for grapes and a few vegetable seeds. Items like ropes, bicycle spares etc. are also available. The MRTC supplies some cereal- and vegetable seeds, pesticides (f.e. for grapes and for storing grains), veterinary drugs etc. In general however very little external inputs are used.

The marketing structure is also poor. Until ten years ago farmers could only sell their products via the cooperatives. As they only bought maize and no sorghum or millet it stimulated the production of the first. At the end of the eighties local middlemen started to buy crops again. They simply store it and sell it at the time of hunger. In the last few years this has increased. In good years also traders from Dodoma come to the villages and buy grains, in bad years they hardly come. Then people have to sell to the local middlemen or bring it to the local markets where traders from Dodoma come or they have to take it to Dodoma themselves.

Figure 8 Despite the lower income, the trade with Dodoma town increases due to the liberalisation policy of the GOT

The poor marketing structure makes that even in bad seasons the price of the crops after the harvest is low. This forces people to sell too much of their crops immediately after the harvest (for schoolfees, tax etc.) while later they have to buy it back for higher prices. The MRTC assists people in trying to prevent this. It stimulates small women groups to put part of their harvest apart as a saving. The amount put apart is doubled via a loan from the MRTC. When prices have gone high the grains are sold and the loan is paid back. The profit is ploughed back in buying again new grains. In principle this is the same as local traders do, but is has the advantage that more people profit from the profit made and it helps to train people in organising themselves. A last advantage is that some members of the group can buy grains from the group at a lower than the market price. Specially in M. Makulu it worked well in the 1992/93 season.

3.7 Agricultural extension services

There are 7 agricultural extension workers in the division. Two are livestock trained extensionists and 5 are crop oriented but all are supposed to cover both animal and crop production. Unfortunately nearly all civil servants in the area are non-Wagogo, because of the low educational level of the Wagogo compared to other tribes in Tanzania.

Within the extension department 2 programmes are running: NALERP (National Agriculture and Livestock Extension and Research Program of the Worldbank) and Global 2000. NALERP covers the whole division and is supposed to give the VEW's regular training. In practise this hardly takes place. Every VEW is supposed to have 48 contact farmers who are advised on a plot of 10 by 10 meter. As no inputs are provided with the message it is not taken very serious by both the VEW's and the farmers.

Global 2000 worked in several villages between 1989 and 1993. It gave seeds of an improved sorghum variety (Tegemeo), fertilizer (both N and P), a seed dressing and if necessary pesticides to contact farmers; all as a loan. They also train farmers to plant in lines. The program is supposed to get 10 farmers per village in the first year and for every successful (repaying) farmer 9 are added next year. After 3 years in theory 1,000 farmers are reached and the program stops. The farmers are supposed to continue on their own. In this they are supported by the program which puts all the repaid loans into an account for the farmers. This account would serve as a bank guarantee for the commercial loans for which the farmers can apply to continue the use of inputs after the withdrawal of the project.

In Mvumi Makulu the program started in 1989 and until 1992 it was a success. In the third season on over 200 acres the message was applied and some farmers doubled or tripled their yields. However in the 1992/93 season when they had to start to buy the inputs cash, less then 10 farmers did do so. No cooperative was formed and the guarantee fund was not used. Many people even question the mere existence of it.

In other villages the program started later and until the 1991/92 season it was quite successful, specially in the somewhat better of villages in the western part of the division (Ilolo, M. Makulu). However in the eastern part is failed completely as the yields were nearly nil. Nevertheless the farmers were forced to pay back their loans, even if they had no food at their homes. This gave a lot of unrest as it was first promised that in case of complete crop failure (due to poor rains) no direct repayment would be necessary.

Next to the extension workers of the ministry of agriculture, also the 8 field workers of HADO are active. Their main tasks are:

- supervision of the destocking (make sure no animals are brought in again and if necessary bring trespassers to court);

- the same for people who cut trees, make charcoal or burn the natural vegetation;
- stimulate tree planting by individuals and villages;
- stimulate and implement other soil conservation measures (like making contourbunds, planting elephant grass along sand rivers etc.).

Their relation with the population is sometimes tense, as they are to give permission for cutting any (branch of a) tree, bringing in any cow for slaughtering, making charcoal etc. This gives them a power position which is sometimes misused. The same goes for the supervision of the destocking, which is generally well implemented but which remains a very sensitive issue with big interest involved.

Figure 9 Extension workers in a farmers field during a field trip

4 THE NATURAL ENVIRONMENT: CLIMATE, SOILS AND VEGETATION

4.1 Climate

The most predominant feature of the climate in Mvumi is the short rainy season from December-April and the prolonged dry season of 7 to 8 months. Table 1 shows the rainfall distribution of Dodoma town, 40 km from Mvumi.

Table 2: Climatic characteristics of Dodoma town

	rainfall			evapo-	temperature		wind-
	average (mm)	highest (mm)	lowest (mm)	ration (mm)	average (°C)	min. (°C)	speed (knots)
January	143	417	13	167	29	18	5
February	114	313	1	153	29	18	5
March	120	288	16	160	29	18	6
April	51	204	2	149	29	18	7
May	5	20	0	166	28	16	8
June	1	74	0	150	27	14	8
July	0	0	0	160	27	13	8
August	0	1	0	188	27	14	10
September	1	1	0	210	29	15	10
October	4	59	0	229	31	16	11
November	20	223	0	209	32	18	9
December	107	264	5	188	30	19	6
year	566	1,083	221	2,123	29	18	8

Source: Christiansson (1981): 32-35

Total rainfall is low: 566 mm on average per year. Ngana (1983) gives 540 mm as the long term average for Dodoma town and 450-600 mm for Mvumi division. Potential evaporation exceeds rainfall in every month. Based on the water balance Ugogo is the most difficult area for crop production in Tanzania. The temperature is suitable for agriculture all year round. Wind speed is high in the dry season when it can cause erosion on barren soils.

The biggest problem is the unreliability of the rains. The column with the lowest rainfall in table 1 shows that in non of the months rainfall is certain. Ngana (1983) shows that the total rainfall in Dodoma town between 1950 and 1982 was less than 500 mm in 44% of the years, less than 450 mm in 30% of the years and less than 400 in 20% of the cases.

Specially the beginning of the rains in November are uncertain. The average rain in November is 20 mm, but the standard deviation is about 40 mm (Ngana, 1983). Many times farmers have to replant (up to 3 times) and many practise staggered planting as also the end of the rains are uncertain.

Ngana (1983) compared rainfall data with the water requirements of the most grown crops and found that all crops normally suffer from water shortage in their early stage of development. This reduces the yields, but not as much as when the flowering crop is hit by a dry spell of 3 weeks or more in January/-February which occurs in nearly 20% of the years (Ngana, 1983). In these cases the total rainfall looks normal but the yields are poor.

How does this compare with the history of famines in Dodoma? Due to shortage of rains between 1950 and 1980, 6 famines were recorded in Dodoma region (Ngana, 1983). This is 20% which compares to the 20% of years with less than 400 mm of rainfall. In another 9 years (severe) local food shortages occurred. So in total 15 of the 30 years were problematic, which coincidences with the years with less than 500 mm of rain and/or a dry spell of 3 weeks or more in January/February.

Heavy showers are another characteristic of the climate. In Mvumi in 1991 out of the 600 mm of rain 400 mm came down in showers of 30 mm or more. Many of these came on consecutive days. This leads to a lot of run off and erosion and a poor infiltration of water into the soil. Specially the 70 mm rainfall on 10 Jan. 1994 caused an enormous run off and erosion as it followed a very long dry season from April 1993 up to 4 Jan. 1994.

4.2 Soils

4.2.1 Landform units and their distribution

Basically 6 major landforms can be distinguished in Mvumi. For the Ikowa catchment (bordering Mvumi), Christiansson (1981) estimated their coverage and gave a short description. Here the same description is given but the coverage is adjusted to the Mvumi situation based on field observations and some data taken from a map of ARDHI:

bedrock hills and ridges	16% of the area; skeletal soil; limited grazing by small stock; scattered fields; some charcoal burning;
upper pediment slopes	16% of the area; shallow red or brownish sandy loams; grazing and limited cultivation; sensitive and marginal zone for agriculture: intense rill and gully erosion;
lower pediment slopes and gently	20%; course to medium textured, pale red to yellowish soils; frequently hardpans occur; due to overpopulation large areas are cultivated; on steeper parts erosion is

sloping upper pediments	severe, on less steep slopes some rills can be observed;
valley floors and plains	30%; nearly flat; grey to yellow colluvial and alluvial soils; 8-20 m deep, above weathered granite; extensive cultivation; densely populated; erosion is limited; wind erosion can be severe on barren lands;
mbugas	2%; flat; black or dark grey alluvial cracking clays; up to 50 m deep; some cultivation on the fringes; if cattle is around it is extensively used as grazinglands;
gently undulating terrain	16%; the micro relief is dominated by the 'pock termite mound pattern' abounded termite hills: slightly doomed circular vegetation-less patches of 10-25 m diameter; course to medium textured soils; grey to yellow; used for grazing and limited cultivation; on vegetation-less patches intense gully erosion takes place.

Only one landform is well suited for crop production: the *valley floors and plains*. Less suitable but also partly used are the *lower sediment slopes and the gently sloping upper pediments*. Limited cultivation is practised on the *gently undulating terrain*. The *mbuga's* can be used for crop production but the heavy soil is very difficult to cultivate and in practice it is hardly used.

4.2.2 Soil types

Farmers in Mvumi differentiate many types of soils, ranging from pure sand soils to pure clay soils. The terminology is complicated as Cigogo and Kiswahili terms are used alongside; table 2 (next page) gives basic terms. To identify soil types is often difficult as many mixtures of soiltypes are encountered and often one soiltype is overlying another as a result of erosion (both geological as human induced erosion, see also Payton, 1994).

The sandy soils (*Msawawa, Isangha and Changalawe*) are found on hill tops and in and around riverbeds. As the landscape in the middle of the division is often undulating and with many hills around, many broad seasonal sand rivers are formed which frequently change their bedding.

The clayey soils (*Isanganyika, Nyika and Ilolo*) are deposited soils in former valleys which filled up with clay eroded from the hills. They can be very deep and usually they form large stretches without much relief. Both *Isanganyika* and *Nyika* can be interwoven with patches of *Ivubi* which is not suitable for crop production: when it rains it becomes muddy and when it is dry the surface dries out very quick, resulting in a dry dusty soil, sometimes crusts are formed.

Table 3: Terminology on the most important soiltypes in Mvumi

Cigogo	Kiswahili	Color	Texture
Msawawa	Mchanga	grey-yellow	pure sand, deposited by rivers
Isangha	Kichanga	grey-yellowish brown	sandy loam soils
Nghuluhi	Udongo mwekundu	reddish-brown	sandy clay loam (few sandy loam)
Ivuhi	Tifutifu	grey	loam soil, high percentage silt
Isanga-nyika	?	dark grey to black	clay loam, no cracks when drying
Nyika	Mbuga	black	heavy clay, cracks when drying
Magungu	Visuguu	red-brown	hardpan/plinthiet
Sakalawe	Changalawe		stoney soils, mostly on slopes

The *Nghuluhi* soils are formed in situ at the lower parts of the hill-slopes. If they are found on steeper parts they are more eroded and the remaining soils are stony and sometimes a hardpan can be seen. If found on more flat sites, they are less eroded, quite fertile and have a good structure. Another term often used is 'Ilolo' which indicates soils which are still every now and then flooded, so usually they are clayey/fertile and have a high water table. In one village (Mvumi Makulu) another soiltype is common: Ibebe soils which are (sandy) loam soils with a whitish colour.

During the RRA (1991) of 118 fields the soil type and the principle crops grown were registered. Out of this only 2 were pure sand (*Msawawa*) and only 2 pure clay (*Nyika*). As can be expected no pure loam soil were encountered (*Ivuhi*). Of the remaining 114 soils most were *Isangha*: 49; second came the *Nghuluhi* soils: 40 times and the '*Ilolo*' type scored 15 times. Of course a lot of intermediate soil types exist or mixtures of soil types.

In Mzula 16% of the area consist of *Isangha* soils and only 3% of *Nghuluhi* (Kaaya, 1993). The general impression is that Isangha soils are the most common, they occupy probably about two third of the arable area.

4.2.3 Agricultural potential of the soil types

Three factors determine the usefulness of a soil in Mvumi:

- fertility;
- workability;
- water regime.

Fertility

The natural *fertility* increases with the clay content. The actual fertility can be different, due to the history of field. Table 3 summarises the available data on soil fertility in Mvumi: one sample from Mvumi Mission (a *Nghuluhi* soil) and three from Mzula (one *Nghuluhi* and two *Isangha*). All are from cultivated fields. The field in Mvumi Mission is in all aspects better than the fields of Mzula which most probably have been cultivated for a much longer period (as Mzula was the first settlement in the area and Mvumi Mission only recently became important).

Table 4: Soil fertility of 4 fields in Mvumi

soil:		texture	pH (KCL)	org.C (%)	N-tot. (%)	P-Bray (mg/kg)	CEC (me/100g)	base saturation
Nghuluhi:								
	a	SL-SCL	6.0	0.65	0.07	16	5.2	97
	b	SCL	4.9	0.21	0.05	4.2	5.9	69
Isangha:								
	c	SL	4.8	0.22	0.04	4.2	2.9	59
	d	SL	5.3	0.16	0.03	3.2	4.3	67

Sources: a: average on the MRTC field trial; b-d: Kaaya (1993).

A striking element in the table is the very high C/N ratio (5) in the samples from Mzula. This is too high and most likely the org. C content is actually higher, as many of the other soils in Mzula have a higher org. C content than the samples in this table. The average of 19 samples mentioned in Appendix II of Kaaya is 0.24%, or an org.matter content of 0.4%. In general the most limiting factor from a soil-fertility point of view is the org. matter content of less than 0.5% and the corresponding low total N of less than 0.05%. On the other hand these are normal values for fields in semi-arid areas. Also available P is low except in the Nghuluhi soil in Mvumi Mission. The pH is fairly high which results in a reasonable base saturation.

Workability

The *workability* is better with an increasing sand content. *Msawawa* and *Isangha* soils can be cultivated very easy. All loam soils (*Ivuhi*) and some sandy loam soils (mostly *Isangha*) become very hard when they dry up. This is a problem in the eastern part of the division where the soils are more shallow and dry up quickly. In some places (Idifu) the soil is already difficult to work after a dry spell of 2 weeks, which occurs several times per season. *Isangha-nyika* soils can be cultivated although they are heavy. *Nyika* soils are too heavy to cultivate with a handhoe when it is dry. When it is wet it is too muddy to work on.

Water regime

The *water regime* of the soils consists of several aspects: water infiltration, water retention and drainage and the water table. The *water infiltration* is of major importance as most of the rain comes in heavy showers. Sandy soils have the highest infiltration rate, clay soils the lowest. The high infiltration in sandy soils makes it possible for dry planted crops to germinate and survive even after one shower. The same high infiltration makes that the natural N-flush (which occurs after the first rains) is quickly leached to deeper layers where it can not be reached by the small roots of the germinating crops. This process makes dry planting on sandy soils very attractive or nearly a necessity.

In clayey soils the infiltration of the (first) rain is less and a bigger shower is needed to make the seeds germinate. Small showers only cause the seeds to germinate and then dry up. The slow infiltration reduces the leaching of *N* after the first rains, again making dry planting less attractive. The slow infiltration of clay soils makes it possible to grow paddy behind small man made dams.

The *water retention and drainage characteristics* of a soil are two sides of one medal: a soil must be able to store as much water as possible but at the same time it must be able to drain excess water so that roots of crops get enough air. Clay soils can store a lot of water but their drainage is very bad, sandy soils have the opposite characteristics. The soils in between (*Nghuluhi*) have the best water retention and drainage regime.

The last aspect of the soil water regime is the water table. A high water table in valley bottoms makes it possible to plant (quick maturing) crops at the end of the rainy season. Specially in the western part of the division there is an extensive area of sandy soils overlying clay deposits with a high water table. Here long term maize, sugarcane and tomatoes can be grown. In some area in the eastern part very shallow sandy soils cause crops to dry up already after a dry spell of 2 weeks (f.e. in Idifu).

Which type of soil is the best depends not only on the mentioned aspects but also on the crop grown. In paragraph 5.2 the interaction between soil types and crops is discussed.

4.3 Vegetation

Due to the heavy overgrazing in the past not much original natural vegetation is left. Basically 4 types of vegetation can be distinguished: bushland, woodland, wooded grassland and grasslands.

Bushland is the most common type of natural vegetation. The most dominant tree species are Acacia sp., Combretum sp. and Comniphora sp. The grass layer consists of annual herbs and grasses, the major ones being Hyparrhenia sp. and Themeda sp.. When this vegetation is really dense it is called a thicket.

Woodland has nearly disappeared in Mvumi. It consists of trees which crowns are touching each other. Next to the above mentioned species the real 'miombo' tree (Brachystegia sp.) is prominent in the woodlands. Also the baobab (Adansonia digitata) can be part of it, although this is more found in wooded grasslands. Grasses are again the already mentioned ones plus Aristida sp. and Eragrostis sp., both also annuals.

The *wooded grasslands* were common in Mvumi, but the overgrazing has turned them more into bushlands and thickets. Still it can be seen in the outskirts of the division where overgrazing was not that severe (Chinoje, Igandu and Miganga). Baobabs are very prominent in these areas.

Grassland can be found in the extended mbuga's, f.e. in Idifu. Many grasses may be found there, next to the already mentioned ones also Sorghum spp. have to be mentioned.

After the destocking the vegetation in Mvumi recovered remarkably well. Only in a few places still barren soils are found (a.o. in Mvumi Makulu, Ilolo and Ndebwe). The 'new' vegetation consists mostly of Acacia shrubs and grasses. Specially the Acacia shrubs slowly develop into an (unpassable) thicket.

Figure 10 The characteristic baobab

5 LAND USE

5.1 Introduction

Before the different sub-systems of the farming system are discussed in detail in the next chapters, here the relations between the sub-systems are analyzed. This means that we talk about land use issues. To start with the land suitability is discussed, followed by an explanation why with growing population pressure the land use had to change from primarily livestock to primarily crop production. The related issue of erosion is treated next before the present land use and the size of the holdings is discussed. In the last paragraph land use planning is discussed, but before that can be done first the present situation on land right is explained.

5.2 Land suitability

Careful screening of an ARDHI land suitability map gave the following results: 7% of the area in Mvumi division is prime arable land. It has no specific restriction for crop production. Twenty five percent is arable land where drought resistant crops can be grown. Next to this villages occupy 9% of the area which is partly arable. So at the maximum 41% of the area can be cultivated. As all houses, roads and (sand) rivers are also in the mentioned areas, as well as some areas where the soil is too salt for crops, in total probably 35% of the area can be used for cultivation. In the western part this is around 50% and in the eastern part is slightly less than 30%. The next table shows the land suitability and the population density for the whole division and for the western and eastern part separately.

Table 5: Land suitability in relation to population density

	arable land (%)	grazing area (%)	conservation area (%)	inh/-km²	inh/km² arable land	LU/km²
total area	41	26	33	76	185	35
western part	61	9	30	117	195	57
eastern part	34	30	36	58	171	25

Explanation: western part is M. makulu, M. mission, Muungano, Mzola and Ilolo
Source data: ARDHI map

The table shows that although in the western part the population density is higher, the number of people per ha of arable land is not much different. If the number of livestock are included then it is clear that the western part was far more overstocked than the eastern.

If the data per village are compared it appears that there are huge differences. In Mvumi Mission there are 308 people per square kilometre of arable land, so per capita only 0.32 ha is available. With the technology used at present this is not sufficient even for pure subsistence. Indeed quite some people of Mvumi Mission cultivate fields outside the village, f.e. in Makang'wa or Iringa Mvumi. Also the malnutrition rate of the village is indeed higher than in any other village. Other villages with less than 0.4 ha per capita are Ng'hahelezi and Igandu. Specially in the last case this is possibly caused by some areas which were classified as grazing areas while they are also suitable for cropping. The villages with the lowest population pressure are Chinoje, Chanhumba and Miganga. They lay at the outskirts of the division and have about 1 ha of arable land per capita.

The table shows that 36% of the area needs to be protected in order to prevent environmental degradation. This leaves 64% of the area for potential grazing areas. If the carrying capacity of the grazing area and of crop residues is both 3 ha per LU nearly 15,000 LU could be kept in the area on a sustainable base.

5.3 The historical trend: competition between crop and livestock

Traditionally crop production and livestock went well together, or more correctly they just existed alongside each other. Except from the cows eating the crop residues there was hardly any interaction between the two sub-systems. The manure from the kraals were only used after the colonial administration launched a large campaign on it in the 1950's. As the area became more and more overstocked and overpopulated a competition between the two sub-systems was inevitable. Slowly crop production became more important, the next table (with data from chapter 6 and 7) shows why.

Table 6 Comparison of livestock and crop productivity with present technology and current prices

	kcal/ha (1,000)	kg protein/ha	kcal/ hour	gr. protein/hr	Tsh.-/ha	Tsh./hr
livestock	22	4	100	19	9.550	42
crops	1,700	45	2,600	69	22,000	34

The estimates from the table show that crop production is superior to livestock production in terms of nutrition. So if land becomes scarce it is necessary to use all arable land for crop production in order to feed the population. As the crop residues of one hectare have more or less the same feeding value as one hectare natural grazing land the number of cows can stay the same when the population increases. So while the area cropped will increase with the population density the number of livestock will stay the same and drop in terms of LU/cap. Although Hadjivayanis (1987) explains that this process was speeded up (or even enforced) by several policies of the (colonial and present) government it is basically a technical necessity.

That it has happened is shown by the fact that the cropped area per capita in Ugogo has remained constant in the twentieth century: 0.4-0.5 ha. (Christiansson, 1981; AHT, 1984 and MRTC-RRA, 1991) while the number of livestock/-capita steadily declined from about 2 LU/capita to 1 LU/capita (Christiansson, 1981) or even less as in the case of Mvumi. As a result the price relation between grains and meat changed over the years. Discussions with elder people in Mvumi (supported by data from Ruthenberg (1964) indicate that in the 1930's the value of 1 LU was equal to 100 kg of grains, at the time of independence (early 1960's) this was about 300 kg of grains while today it is over 600 kg of grains. So as the importance of livestock vis-a-vis crops is reduced, its products become scarce and its relative price rises which keeps livestock production still profitable: so its financial returns per hour are similar to that of crop production as is also shown in table 6. The income per hour in the table is higher for livestock production but it involves also more capital. If one LU is estimated to cost 25,000 Tsh. and the owner wants a return to his capital of 5% p.a. the income per hour is 36 Tsh, equal to crop production.

5.4 Erosion

As mentioned in par. 2.2 Mvumi has had a high population density for over hundred years. The many people needed large areas for crop production and a lot of wood. As they opened fields and cut trees, grasses established themselves very easy. The large number of animals ate these grasses (and the stalks from the fields) and left the erodible sandy loam soils prune to the strong winds of the dry season and the heavy poordowns of the wet season. The same animals also ate the vegetation on the hills, causing the run off to increase, resulting in even more water-erosion on the fields.

When Stanley was on his way to find Livingstone he already noted that Mvumi was a dusty place. Afterwards this worsened as hundred thousands of people passed Ugogo as members of the caravans which trekked from the coast to Tabora. One of the main routes passed straight through Mvumi division (from Handali to Mvumi Makulu) and logically put high demands (in term of food and firewood) on the natural resources of the already densely populated area.

The colonial government took some measurements against erosion, but as they usually tried to enforce these measures to the farmers, the results were very poor. Mzee Wilson Chizinga from Ilolo recalls: from 1947 to 1951 contourbunds were to be made, from 1951 onwards Euphorbia was planted in and along gullies and from 1954 onwards some fruittrees and Cassia siamea were planted at all kind of places. Mzee Wilson Chizinga remembers that from 1954 onwards he (as a 'mpembamoto') went along with colonial officers to force people to use FYM on the fields. After independence the government neglected anti-erosion measurements for a long time as this was associated with colonial rule.

After independence some political decisions even speeded up the erosion problems. The 'luwindo' enclosure system collapsed when traditional leaders lost their power after independence. So all animals just roamed around without a common strategy of conserving resources. The 'milaga' system of privately protected areas for grazing in the dry season, collapsed after the villagisation: as people lived and cultivated in concentrated areas there was no place for private protected areas near the homesteads anymore and protecting an area far from the homestead is usually not effective.

So erosion has been a constant factor in Mvumi. Not only because of the overexploitation as such but also as the soil and the climate are very conductive to wind and water erosion. Payton and Shishira (1994) indicate that erosion might be as much a natural state of affairs in Dodoma as a man-made process.

Farmers have adjusted themselves regularly to the erosion. In Mvumi farmers do influence the run-off and the resulting sheet wash. Some smaller gullies (up to 3 meter wide and 20 cm deep) and sand rivers are sometimes plugged with branches of the baobab together with small twigs and sand. In other occasions cut-off drains are made which diverts the flow of water and sand. Another control mechanism is leaving strips of grasses at the right place.

The final aim of these interventions is not always to minimise erosion but to optimise it: sometimes more sand is needed on the field and sometimes less. A woman in Ilolo was found to be happy with the 6 cm of sand washed over her millet crop in January 1994. She said the sand was needed to bring more fertility and to reduce the evaporation from the then sub-soil. After two years the smaller particles would be blown away by the wind so she would like another layer of 6 cm. Millet and other cereals can withstand sheet wash reasonably but groundnuts can not.

Another aim of the management of the erosion processes was to get a good layer of sand over a more clayey soil with the aim to grow sweet potatoes on it. This is a typical example how farmers make use of the new possibilities offered by erosion. In March 1962 a heavy poordown caused several fields in Mvumi to be covered by a thick layer of sand. As it was too late to replant cereals one of the owners of the fields (Mzee Zoia) tried to grow sweet potatoes (which are normally planted in March). He succeeded very well as the potatoes developed easily in the new sandy topsoil while the roots of the crop penetrated in the fertile subsoil. At the end of the 60's this way of planting sweet potatoes had become popular all over the division. People also started to grow them in some sand rivers which had a appropriate subsoil. Some households specialised in sweet potato production and stopped growing cereals.

In general many people in Dodoma rely for their water supply on the run off water stored in the sandrivers. This all is not to say that erosion is not a problem. It is also perceived like that by farmers. So when in the 1980's the problem grew beyond any control of either the government or the farmers it was decided to destock the area. The results of this are discussed in 7.4.

Data on erosion are not available from Mvumi, but Christianson (1981) found in Kikombo (which borders Mvumi) run off rates of 20% of total rainfall in small catchments. In larger catchments this was reduced to only a few percent as most of the run off water is stored in the big sand rivers. The resulting denudation on the pediments was found to be in the order of 1-10 mm per year, depending on the length and the steepness of the slope and on the intensiveness of grazing. The soil erosion ranged between 2.5 and 9 ton/ha depending on many factors.

More detailed information is available from Mpwapwa where in the 1930's and 1940's a lot of research on erosion was done. Temple (1973) reviewed the data on the base of earlier publications of Staples (1936) and Rensburg (1955). It shows that any vegetation cover is crucial for erosion prevention. Over 8 years (with on average 690 mm of rainfall) grass plots had a run off of about 5% of the rainfall and the soil erosion was less than 1 ton/ha per year. Cultivated plots had a run off of 19% and a soil loss of 55 ton/ha. Bare plots had a run off of 50% (with on average 620 mm rain) and a soil loss of 147 ton/ha.

Of course all this depends a lot on the actual local situation like the steepness and the length of the slope, soil type etc., but it can be safely assumed that due to the environmental degradation 20% of the rainfall is lost for crop production. The resulting soil erosion is probably around 5 ton/ha on normal land up to 50 ton/ha on field on slopes. As the soil washed away from a field contains relatively more small particles than the original soil it usually has a higher content of organic matter and nutrients. This 'enrichment' is often a factor two. So if 5 ton of soil is lost per ha and the soil has a N content of 0.05% the loss of N is 5 kg/ha.

5.5 Present land use

Apart from the few households practising zero-grazing (which will be dealt with later) the only land use after the destocking is cropping. Basically four crop systems can be distinguished.

The major one is the 'migunda' fields which occupy about 84% of the area: 60% with millet as the major crop, 12% with sorghum, 12% with maize. In the western part there is relatively more maize.

The next in importance is the 'vigundu' fields on which groundnuts and bambara nuts are grown. These crops occupy about 12% of the area.

Table 7 shows which of these major crops is grown on which type of soil. The 5 soil types are reduced to 3 groups: sandy soils (*Msawawa*, *Isangha*), sandy clay loams (*Nghuluhi*) and clayey soils (*Isanghanyika*, *Nyika*).

Table 7: Interaction between soil types and crops

Soil types:		Sandy	Nghuluhi	Clayey
% of all fields:		47	37	16
% of principle crop grown on soil type	millet	59	38	3
	maize	43	29	29
	sorghum	37	42	21
	groundnut	62	29	10
	grapes	18	64	18

Source: data from the MRTC-HRA (1991)

Millet is drought-resistant and can not stand waterlogging so it is preferably grown on sandy soils. It is also able to withdraw more nutrients than sorghum from poor soils because it roots quickly and deeply. Sorghum is also drought resistant (although less) and stands waterlogging well, so it can be grown anywhere. Maize is not drought-resistant and needs fertile soils: clayey soils. Groundnuts prefer lighter soils so that the nuts develop well and harvesting is easy. Grapes need a well structured, fertile soil. The *Nghuluhi* soil is well structured and the fertility is increased by putting FYM in trenches under the grapes before planting.

The third crop system is the fields of tomatoes, sugarcane, sweet potatoes, cassava and cowpeas. It occupies about 3% of the cropped area, of which 1% is sweet potatoes, 1% is cassava (spec. in the western part) and 1% intensive (commercial) vegetable production.

The last 1% is permanent cropping of grapes and bananas as cash crops.

5.6 The size of the holdings

In the past in central Ugogo 1.34 acre was cultivated per adult (Rounce 1949, in Rigby, 1968) which equals 1 acre per capita when the population growth is 1.6% p.a.. However in 1949 also 2 LU per capita were available.

More recent surveys in Dodoma indicate that the average household owns about 1 acre per capita. In the beginning of the 1980's RIDEP found 2.2 ha for non cattle owners and 3.8 for cattle owners in Mundemu. The SPWP survey found 2.5 ha per household. Two surveys in M. Makulu found an average of 3.2 (ARDHI, 1988) and 3.1 ha (Manota et al. (1992). In the RRA of 1991 an average of 3.4 ha was found for 6 villages in the division. As land is more scarce in Mvumi the data from Mvumi must be an over-estimation due to the non-at-random sampling of the households visited.

A better standard for comparison seems the cultivated area per household member. In Mundemu the area per capita was 0.39 ha for non cattle owners and 0.49 for cattle owners. The SPWP survey found that 0.41 ha/cap. was owned of which 13% was left fallow. Unfortunately the reports on the surveys in Makulu do not indicate the household size of their sample. In the RRA of 1991 people owned 0.43 ha/capita, of which 12% was left fallow (mostly unpurposely). Seeing the low yields one acre or 0.4 ha/capita seems the absolute minimum for survival (see 6.9).

If on average per capita 0.43 ha is used for crop production then in the whole division 23.381 ha or 32% of the total area is needed. As in 5.2 it was estimated that about one third of the total area is suitable for crop production this means that a further expansion of the area under crops is hardly possible. Indeed people start to cultivate on steeper slopes again these days, f.e. in the western area in Muungano, Mzula and Ilolo. Also more and more the heavy clay soil are used, f.e. along the road between Mvumi Mission and Iringa Mvumi.

5.7 Land use rights

The legal situation on land rights as described here is based on a (draft) paper on land rights of the Dodoma Land Use Management Project (Mwangoka and Slootweg 1992).

All land in Tanzania is publicly owned and vested in the state. Land can not be the property of someone and is thus not a commodity. However someone can have a right of occupancy. There are 2 types of statutory rights of occupancy:

1. deemed right of occupancy;
2. granted rights of occupancy.

ad 1 One can claim to have a deemed right of occupancy if one is a native and if this right is recognized by the local authorities. The deemed right is not registered and has no fixed time period. No landrent is paid and selling, leasing, mortgaging and devolutions upon death/ divorce follow customary law.

ad 2 A granted right of occupancy is registered as a 'certificate of title', commonly known as a 'title deed'. The title deed owner has to pay landrent and the period of the right of occupancy is fixed. A title deed can be subleased, mortgaged or sold with consent of the President. In case the holder dies or divorces the title deed is subject to the common law.

Practically all land in Mvumi is owned according to the local customary law, this means that somebody owns a piece of land as long as everybody in the community agrees on it. In case of disputes the local government (i.c. the village government) decides, if they can not settle the matter it is taken to court.

In practise most land already belongs to individuals or families for a long time. The basic unit owning the land is more the family than the individual. Within a family land can be reallocated to somebody else or it can be sold or rented out. In the eastern part of the division there is still some unused land left, but this is mostly of marginal quality. The village government can give it to anybody who asks for it. In other villages (f.e. Ilolo) few people have large stretches of land which they give/sell and rent to others. In again other villages (M. Mission and M. Makulu) there is no unoccupied land left.

Traditionally the Wagogo consider a piece of land community property again after is has been left for two years without cultivation. In Mvumi this does not happen often as the pressure on land is very high. Even if somebody does not want to use it for several years he/she will immediately be asked to rent the land for the period. For one year people give land free of charge, or they ask a small rent (f.e. 1.000 Tsh. per acre, 1991/92 prices). Sometimes the owner of the land even looks for somebody to cultivate the field for one year. As a rent the cultivator has to clear the many thorny young Acacia shrubs and nasty grasses which germinate if a field is left fallow for 1-2 years.

Selling of land occurs quite often. The prices differ according to the type of soil. The best soils which are suitable for grapes, are sold for up to 20.000 Tsh. per acre, while a sandy soil which is only suitable for millet, costs only 3.000 to 5.000 Tsh per acre (1991/92 prices). The small areas suitable for sugar cane production can be sold for up to 60.000 Tsh./acre (1993 prices; Minderhoud, 1993).

All villages have their village fields for communal purposes. Most were 100 acres or more. In the past the village government used to allocate subplots of this 'ujamaa field' to every family. The yield was shared between the family and the village. In practice the yields of these fields were very low, many times nothing was harvested at all. Recently is was decided that villages can rent this plot to families for a fixed amount. Most villages decided that the rent for the 1992/93 season will be one tin ('debe') of grains (= 16-18 kg) per acre. The farmers responded positively to that and most of the 'ujamaa fields' are now divided in one acre plots for individuals.

After HADO came in the area, opening new land on hill sides became illegal. So these days people open new land without informing or asking anyone. This is more or less silently accepted by the village government. Sometimes HADO arrests people for this, but not often.

An important discussion is in how far the land rights situation is favouring or obstructing agricultural development. Many times it is stated that insecurity of land rights, specially for women, is a reason for people not to invest in their land. During the RRA some respondents were explicitly asked about this but all denied this. They indicated that their security depended more on a good relation with their husband than on an official law. As long as they can be beaten up by their husbands on smaller issues than a piece of land they would not dare to use their official rights which might be denied by a local court for the sake of some money. Another aspect is that also women find it normal and right that land belongs to the family and not to individuals. For them it is socially far easier to go back to her family and get land there, than f.e. staying with the family of her husband after he has died. For them other issues like being able to keep their children with them after a divorce seem more important than the issue of land.

5.8 Land use planning

Land use planning refers to a process whereby it is tried to solve (possible) conflicts between different land users by regulating the land use. The final aim is to come to an optimum use of the natural resources in a social-economic acceptable way.

The conflicts can be on several issues: crops versus livestock, upstream cultivating farmers against down stream users, present generations versus future generations and land ownership/land rights (f.e. women versus men, poor versus rich, local people against outside investors etc.).

From previous chapters it can be concluded that there are hardly any conflicts on land ownership between poor and rich and between local people and outsiders simply because the latter are not interested in the land.

In Mvumi two major land use planning programmes have taken place and a third one is implemented at the moment. The first one was the villagisation which was not a land use plan in the strict sense but it had great consequences on it. First of all it led to a concentration of people in small areas where the natural resources were quickly over exploited. It also affected the spacial arrangement of the fields. In the past people lived on the better soils where they could make their 'vigundu' fields around their homestead. The Ujamaa villages were however not always well planned from a farming point of view, so people found themselves living on very poor soils (f.e in Idifu). As a result a 'vigundu' is no longer a 'homestead field', it can be anywhere as long as the soil is fit for bambara and groundnuts or f.e. sweet potatoes.

Sometimes villagisation reduced the pressure on the land as in some places farmers with a big herd (f.e. more than 50 heads) were not allowed to enter the village. As they went elsewhere some experienced severe losses of animals as a result of salt water, scarcity of fodder and water and local farmers who refused to receive them and their herd. It is also likely that the increased distance between the people and the bush led to an overall reduction in the consumption of firewood. In other words the pressure on the former areas of living was reduced. Indeed some people say that the number of trees in Dodoma has increased in the last decades. Partly also because active tree planting campaigns have been fairly successful in the villages.

Secondly the villagisation led to the collaps of the 'milaga' system as there was no longer any space for them around the homesteads or fields of livestock owners. It also led to a sub optimal agricultural production due to the long distances between the homestead and the fields. Also theft might be increased for this reason. This again makes people shy to invest in their far away fields. A last problem is these days that the zero-grazing farmers have to spend a lot of time on collecting fodder. It is clear that from the point of view of optimising the use of natural resources, it would be advisable to allow farmers as soon as possible to go back to their former homesteads.

The second land use planning project was the destocking by HADO which actually solved the conflict between livestock keepers and crop producers at the detriment of the first. It also improved the balance between the use of available resources by present and future generations by making the land use more sustainable.

At present the Dodoma Land Use Management Project (DLUMP) is doing a participatory land use planning in Mzula village. The way the project operates is a major step forwards compared to all planning exercises previously done in the area. From the beginning people were as much as possible invited to think together with the project staff. Not only its participatory approach was new, but also its aims. The final aim was to improve the management of the natural resources and to issue title deeds to individuals, both men and women. Although this is still very ambitious it is far more realistic than many plans in the past which also aimed at land redistribution.

Of course the new methodology of DLUMP lead to an interesting learning process with all kind of practical problems, the most important one that it turned out to be too expensive to really issue individual title deeds (Kikula, 1994). A more fundamental problem appeared to be that there are hardly land issues to solve in Mzula: no conflicts between livestock and crops, no conflict between poor and rich etc. Only giving title deeds to women can be regarded as positive although it is doubtful how efficient that would be (see above). The second fundamental problem is that no improved land use husbandry techniques are easily available (as also shown in this report).

6 CROPPING SYSTEM

6.1 The cropping sub-system

In the cropping system four types of fields are distinguished. Most important are the large fields ('migunda') of dry planted cereals. They occupy around 80-85% of the planted area. Bulrush millet is the most important crop followed by sorghum and maize (which is steadily increasing around towns and big villages since the 1950's). On most fields intercropping with minor crops like cowpea, lab-lab and cucurbitaceae is practised. Part of the 'migunda' are also the homestead plots ('machito') where often maize is grown and which are the first to be cultivated after the rains have started. This maize is to yield the first food of the new season.

Smaller plots ('vigundu') with bambara and groundnuts in a pure stand occupy 10-15% of the area. They are dug immediately after the first rains (of course after the 'machito') before being planted. Groundnut replaced the bambara nut more and more after the second world war.

About 5% of the area is occupied with sweet potatoes (specially since 1960), cassava (since 1970), tomatoes and grapes (since 1980) and sugarcane (since recently). Land preparation and planting is done towards the end of the wet season (March). In Cigogo these fields are just named after the crop (f.e. for sweet potatoes: 'mgunda wa mandolo').

Figure 11 Planting on the 'migunda'

In all fields crop residues are either eaten by livestock or burnt before the next season. Although soil fertility is decreasing, the yields seem to be fairly constant for the last 50 years: 500 kg/ha in years with a normal rainfall. This can be explained by better husbandry methods, in particular deeper digging and more frequent weeding. The more intense land use also reduced the invasions of Quelea-quelea birds who found less place to make their nests (in trees and in tall grasses).

6.2 The crops

6.2.1 Staple food crops

The most important food crop is bulrush millet, followed by sorghum and maize. The first two are drought resistant and produce better in years with little or irregular rainfall. In average or good years maize yields more. As people in towns prefer the taste of maize it has a better market.

For all the 3 major food crops different varieties exist. The traditional millet is remarkably uniform; mostly one variety is used: 'Uhemba'.

The most important sorghum var. are Lugugu, Mhoputa and Bangala (long straw, open head, white seeds) and Sandala (medium tall, compact head, white seeds). Several years ago the Serena was introduced with red seeds, compact heads and short straw. It produces quite well but it was rejected because of the bad taste. In the 1980's Tegemeo was introduced, also a short straw variety with a compact head, but with white seeds and a better taste. In the last four years it became fairly widely accepted, although it did not fulfil the earlier high expectations.

For maize there is a local variety which name seems unknown. Progressive farmers know and use improved varieties like Katumani (quick maturing), TMV-1, Staha (intermediate term) and Ilonga (long term). In 1993 Cargill started to distribute some seeds free of charge (via the Min. of agric.) of a short term var. called CG 4141. Farmers liked it very much, but in 1994 the price was about 500 Tsh./kg, so very few buy them.

The bambara nut is a minor staple crop. It is grown in pure stand on the 'vigundu'. People say that it can not be intercropped because it has very sensitive roots. It is a women's crop which needs a lot of attention.

Also sweet potatoes, planted in March, are mostly grown in pure stands. They are cultivated on ridges. Cassava increased since the destocking and is grown both in pure stand and intercropped. It is often used as a payment for daily labourers in the beginning of the rainy season. A major draw back is that it can only be preserved on the (far away) field, where it can easily be stolen.

6.2.2 Cash crops

Groundnut is the most important cash crop, grown on the 'vigundu' by nearly all families. Two types exist: the long term creeping one and the short term more erect one. The last one is grown most, mostly in pure stand. The short term variety came from the Kongwa groundnut scheme and has replaced the traditional long term variety very slowly over the years.

In the western part (on the red soils) grapes are an important cash crop, but only for big farmers as it involves large investments. As grapes are a permanent crop and it needs the best soils it is a threat for the self-sufficiency of food in the area. A major handicap is the marketing. In 1993 DOWICO (Dodoma Wine Company) who used to buy all grapes virtually collapsed and many farmers have not been paid for their last harvest.

After the destocking sugarcane became an important cash crop in the valley between Mvumi Mission, Mvumi Makulu and Ilolo. In four smaller pockets, in total about 50 acres, it is grown together with sweet potatoes and tomatoes. In total probably up to 100 people have a plot of 0.1-0.5 acre which yields on average 200.000 Tsh. per acre (Minderhoud, 1993).

6.2.3 Vegetables and fruits

Vegetables are grown in most 'migunda' fields: many Cucurbitaceae (pumpkins, calabashes, watermelons, gourds), some legumes (lablah, cowpea, pigeon pea), some leaf vegetables (spinach and Amaranthus sp.) and some fruit vegetables (tomatoes and Lady's finger).

From February onwards pure stands of cowpeas and sweet potatoes are planted in 'gardens' in sandy riverbeds. Both produce next to their seeds or tubers very nutritious leaves. For cowpea these are the main reason for the cultivation. As the destocking reduced the water in the riverbeds it also led to less cultivation of cowpeas and sweet potatoes.

Some leafy vegetables germinate naturally in or around fields. Specially towards the end of the rainy season they are collected, sometimes first cooked, dried and stored in pots or calabashes. The main ones are: 'mlenda' (a Cruciferea), 'mzimwe' (Gynandropsis gynandra), 'cicwili' (a Cruciferea) and 'chiwandagulu' (Ipomoea sp.). In a normal season people can collect enough vegetables to eat dried vegetables for the whole year.

In the western part of the division some people practice intensive gardening. In Muungano mostly tomatoes are grown and in Mvumi Mission sugarcane, sweet potatoes and tomatoes. In Ilolo mostly tomatoes are grown.

The tomatoes are mostly seeded before the rainy season, so they need to be watered. When the rains start they are transplanted. If this is on a sandy soil FYM from outside Mvumi division is used (Mapinduzi and Ng'hong'hona). On heavy soils no manure or fertilizer is used. The first harvest is in January/February when the prices are still very high, later (in April/May) the prices are very low. Many people walk with their produce to Dodoma town at night. Nowadays some cars do part of the transport (sometimes the tomatoes are even taken directly to Dar es Salaam). The best income is obtained when the tomatoes are planted at the end of the rainy season so that the tomatoes are marketed in the dry season, but as this needs a lot of watering few people can practice this.

In the dry climate of Mvumi not many fruit species perform well. In practice only 3 species are found: 27% of the households visited during the RRA had planted guavas, 21% mango's and 15% papaya's. Usually a family owns 1 to 10 trees. The maximum was around 30. A few cashew trees and dates can be found. Natural fruit trees include: 'Mbuyu' (Baobab, Adansonia digitata), 'Mzambarau' (Syzygum cumii) and 'Mlumba' (Ficus spp.), 'Furu' and many others (see also Westman)

6.3 Crop husbandry

6.3.1 Land preparation

The season starts in September/October with clearing all fields. The crop remainings of last year are arranged on heaps or lines and burnt (mostly in two rounds). In this process a lot of N gets lost. After clearing on the 'migunda' planting holes are made and seeds are dibbled in there without any prior cultivation.

When the rains come the tradition prescribes one day of rest. If the rains come with a lot of wind even two days without any cultivation pass. Also during the rainy season any shower with a lot of wind leads to a day of rest. After the rest people start to cultivate their small homestead plot ('machito') and sow maize there. Next are the 'vigundu' which are first dug and then sown with groundnuts or bambara nuts. Lastly follows the 'migunda' fields where the soil between the seedlings (which have emerged now) is cultivated and sometimes new crops (f.e. groundnuts or vegetables) are planted in between and/or seedling are transplanted. This is also the first weeding round.

The cultivation is usually not very deep as the farmers are in a hurry to cultivate an area as big as possible in the short rainy season. All extension programs in the area urge for a deeper digging as it gives a better infiltration and conservation of water and a better rooting, all leading to higher yields. However if the deep digging leads to a delay in planting the above mentioned advantages might be offset by lower total yields as a result of the delayed planting.

6.3.2 Planting

The time of planting is the most important single factor determining the yield. As mentioned on the 'migunda' dry planting is done as a risk avoiding technique which is necessary due to the short and erroneous rainfall pattern. It causes the first rain to infiltrate in the planting hole and the crop will mature before the rainy season is over. It reduces the incidence of some pests like stemborers.

Another advantage is that the seedlings make optimal use of the natural N-flush which occurs after the first showers. Specially in the more sandy soils this N is quickly leached to deeper soil layers where it can not be reached by the initially short roots of the emerging seedlings. As N is the most limiting factor for production (next to water) on sandy soils the difference between dry planting and planting after f.e. one week is tremendous. As the initial root growth of millet is much higher than of sorghum, millet is best suited for the sandy soils.

Of course dry planting does bear the risk of replanting and the first plots ready for harvesting have more problems with birds and thieves. Also in seasons with more than average rain at the end, early planted plots can suffer from fungal diseases before the harvest.

Next to risk avoiding dry planting is very quick. A farmer can plant many acres before the rains and she will choose the best ones to go on with when the rains have come. In this way it promotes extensive cultivation in which the total yield is optimized, but with low yields per acre.

When the germination has been poor or when the rains stopped and part of the seedlings have died, farmers do transplant both millet and sorghum. This is one of the reasons why they plant many seedlings per hole. They uproot the seedlings, reduce the leaves and transplant it, even next day if necessary.

6.3.3 Spacing

The optimum spacing differs between traditional varieties and new ones. For traditional ones many times a spacing of 1 step by 1 step is observed. This seems a wide spacing, but it must be seen as a way of avoiding risks; specially when farmers (re-)plant late, they don't expect much rains and they use a low plant density. When rains are as poor as anticipated these few plants at least get enough water to produce some yield. But if rains still turn out to be good the number of plants is too low to make an optimum use of the available water. In the same way the soil type influences the spacing: in sandy soils spacing is wider.

Thinning could be a way of starting with a higher plant population which is later reduced according to the rains. However it is not practised and also in the extension programs it is difficult to get farmers doing it. One reason may be that the traditional millet varieties easily adjust itself to the actual situation by tillering. So if there are enough nutrients and water it will tiller abundantly. If later a shortage is experienced it will withdraw its nutrients (spec. N) from the tillers and bring them in the mean shoot, so it will still yield well. The many tillers also suppress weeds.

6.3.4 Crop disorders

The major and most constant problem are the weeds. Weeding is done with a hand hoe ('jembe'). It is done after germination and a second and a third time according to the rains and the weed population. Farmers claim that about 75% of all fields are weeded thrice. It is possible, as the high population pressure suggests that there are enough people to do the job. Fields overgrown by weeds are rare. Striga asiatica is found but not much. It is remarkable that not all farmers recognise Striga as a problem, to some it is just a medicinal plant which cures several diseases. It is more associated with cowpeas than with cereals (although it is not S. gesnerioides). The solution of rotation is not known.

The major pests are stalk borers (mostly Busseola fusca and some Chilo spp.), army worms (Spodoptera exempta) and birds (weaversbirds and Quelea quelea). All follow migratory patterns, so one area can be heavily infested while elsewhere there is no problem. Whenever the infestation occurs all three pests can cause very severe damage. There are no local means to do something about this apart from some handpicking of insects or early planting.

However the first field to ripe gets most problems with birds. For the birds there are no good solutions. First farmers cut down the trees in which they have made their nests and if the problems are very severe a plane can be called from Tengeru which will spray the birds with pesticides. This was done in 1991 in Igandu.

Less general pests are aphids (mostly maize aphids: Ropalosiphum maidis), grasshoppers and Blue bugs (Calidea spp.). In general these pests occur during dry spells. Maize and sorghum suffer more from them than millet.

As might be expected in the dry climate of Mvumi, diseases are less prominent then pests. For cereals the major disease is kernel smut ('mang'hiliwi'; Sphacelotheca spp.) on sorghum. In the grapes and the gardens in the western part of the division the most common diseases are: wilt in seedlings (tomatoes, papaya) and early blight and viruses in grapes.

6.3.5 Water conservation

Next to digging, weeding is the most important way of water conservation, specially the arrangement of the earth during weeding. In the first weeding round the soil is taken away from the (small) plant, so water runs towards the plant. During the second weeding round (in January and February with heavy showers) this earth is returned around the (big) plant to form a ridge: earthening up. This improves the water infiltration by reducing the run off and reduces the risk of waterlogging and lodging.

6.4 Intercropping

Intercropping has many well known advantages like increased yield stability, reduction of risks, less problems with weeds, pests and diseases, higher yield per unit area, less erosion and nutrient leaching and a better balanced distribution of labour requirements throughout the season.

In all fields more than one crop can be observed. All kind of minor crops are planted in between the main crops: cucumber-like crops; cowpea; some pigeon pea; watermelon; calabash; vegetables etc.etc. Of the main crops sorghum and millet are regularly intercropped. This is reducing the risk as both have different water requirements during the growing season, specially the long term sorghum can still extract a lot of water from the soil when the rains have stopped and the millet has already dried up.

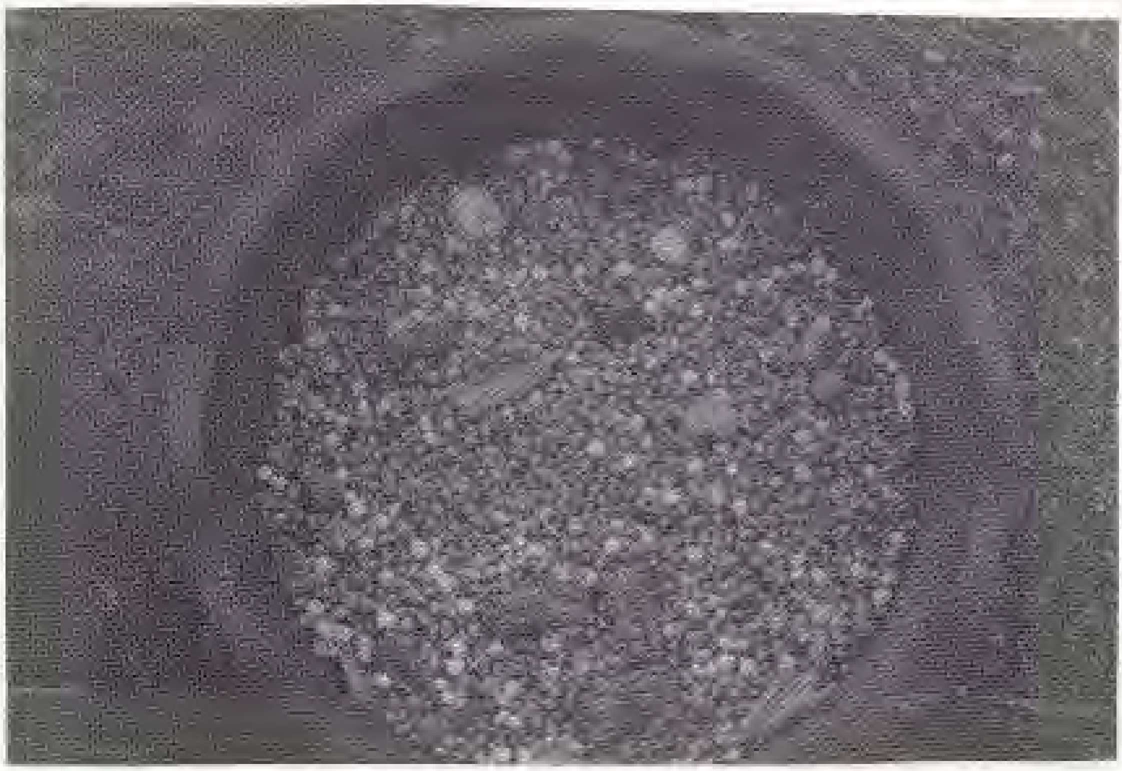

Figure 12 8 species mixed for planting: 3 cereals, 2 legumes and 3 Cucurbitaceae

6.5 Maintaining soil fertility over time

Securing soil fertility over time is the heart of any farming system. If soil fertility is to be maintained at least the amount of nutrients taken up by crops should be returned to the soil. Here only N is taken as an indicator as it is the most limiting nutrient and very sensitive to management decisions.

N-balance of traditional grain crop

It is assumed that per ha 500 kg of grains is produced and that the harvest index is 25%. The N content of the cereals is 1.5% (9% protein) and of the crop residues 0.6% (= crude protein 3.6%). The total uptake is 16.5 kg of N. Losses due to (wind-)erosion are also important: if per ha 5 ton of soil is lost with an original N content of 0.05% and an enrichment factor of 2, another 5 kg is lost (see 5.4). On steeper slopes this can be much higher.

The input comes from: (estimates based on Smaling (1993) and PPS (1985)):

- atmospheric contributions 3.6
- N-fixation by algae 1.1
- N-fixation by legumes 0.0 (see later)
- N-fixation by free living bacteria 0.5
- N in organic matter returned to the soil: 4.0 (45%, see 7.4.2.2)

So in total 9.2 kg of N is added per ha and the N-balance is negative: per year a loss of 12.3 kg of N per ha is experienced.

N-balance of a legume
The amount fixed by legumes can be put at 50% of the N in the areal parts. If a legume yields about 300 kg/ha, has a harvest index of 50% and a N content of 3.5% and 2.5% in the nuts and the crop residues resp., its contains 18 kg of N/ha. The input consists of the 9 kg/ha which is fixed, 5.2 kg from the atmosphere and 3.4 kg (45%, see 7.4.2.2) from crop residues. If erosion causes a loss of 5 kg/ha the balance is a loss of 5.4 kg of N per ha.

In three ways the famer can influence the N-balance. She can try to reduce erosion (or even try to get sand washed over her field, see 5.4), she can try to reduce the burning (to get more N of the crop residues incorperated) or she can try to restore the fertility (replenish the nutrients) via Farm Yard Manure (FYM), fallow periods and proper rotations. The last three option are discussed here. For the others it is noted that using crop residues for fodder is costly in terms of N removed.

Farm yard manure
Since the destocking FYM is not available any more, although in the eastern part of the area many old kraals still have manure. This shows that people are not used to use it. Old people still recall how in the 1950's colonial officers would pass the villages to press people to use manure. The RIDEP survey found that in Mundemu 19% of the households (or 85% of the households having cows) used FYM on their fields. The manure has a very low quality. As it has been exposed to the strong sun and wind for years in the kraals the N-content must be very low, in some cases its application might first lead to a N-fixation. Farmers indeed report that FYM has no effect for the first one or two years. Also a trial by the MRTC gave no positive effect on the use of FYM. A trial at Hombolo research institute in 1985/86 gave very variable results. In total 90 ton of FYM was applied (not incorporated) which yielded and extra 2,560 of sorghum and millet (Chilagane, pers. comm). If the N-content of the FYM was 0.5%, 6 kg of grains were produced per kg of N. As the N is only slowly released in the next few years the same amount might be gained as a residual effect of the FYM. In total this might lead to 12 kg of grains per kg of N, at the lower end of the range of 10-20 kg indicated in FAO (1980). In terms of labour this means that per extra kg of grain 16 kg of FYM is needed. This gives reasonable returns per hour in the case of nearby fields, but not with far away fields.

Despite these problems, how much could FYM contribute if all of it was used? In par. 7.2.6.4 it is estimated that before the destocking 9.2 thousand ton of FYM was available. If this has a N-content of 0.5% this is 2.2 kg/ha. So using FYM reduces the shortage from 12.3 to 10.1 kg/ha.

Fallow
As can be expected from the very high population pressure in the division, leaving land fallow is hardly done. On average the visited farmers had 8.5 acre of which 1.0 was left fallow (=12%). Most farmers said they failed to cultivate it, although they had planned to do so.

Rotations with legumes
The rotation of crops has a positive influence on soil fertility specially when the crops following each other have different soil requirements. A good

rotation include leguminous crops as they can fix N from the air which is added to the soil after they die. Of the fields visited during the RRA of 1991, 78% had the same crop as last year (or the same composition of crops). Six percent had a different crop, but both crops were cereals. Only 10% had a change from grain crops to legumes, making optimal use of rotation effects.

When farmers were asked about their ideas about rotation it appeared that many were not aware of its positive effects. Traditionally millet and sorghum were grown on the same piece of land. Manure and fallow periods (by moving to other areas) kept the soil fertility on a reasonable level. Only bambara-nut, cowpea and pigeon pea were available in too small amount to really practice crop rotation. These days groundnuts are an interesting possibility. Some farmers already practice crop rotation, usually they claim to grow millet/-sorghum for 5 - 7 years followed by two years of groundnuts/bambara nuts. This would mean that 25% of the area should be planted with these leguminous crops. In general this is far less. If the legumes are regularly rotated over all fields every field will have legumes once in 8 years. Seeing the above estimate of N-balance of legumes this has only marginal effects.

In general this paragraph shows that the present cropping system is based on soil mining. Traditional solutions as FYM, fallows and rotations with legumes can reduce the soil mining but not enough. So other ways have to be explored. In chapter 10 several alternatives are discussed: organic farming (green-manure, burying stalks, compost), agroforestry and chemical fertilizers.

6.6 Post harvest aspects

Threshing of the grains is done manually by beating the heads with sticks. After winnowing and cleaning the yield is stored inside the house in a structure of woven twigs: 'kihenge'. It is plastered with cow dung, or clay (which is not as good). It is lifted half a foot from the ground. They can contain up to 1 ton of grains.

The best grain for storage is millet. It can stay for more then a year without significant losses. Maize and sorghum are much worse. For the normal storing period of 6-8 months farmers estimated the loss to be 15-25%. The biggest problems are insects and rats/mice.

To prevent storage losses very few farmers mix a powder of certain leaves ('misaka') with the grains. Most farmers however do not know this method. Seeds for planting are selected from the biggest heads of grains before threshing and put in a calabash together with ash and (rarely) leaves of certain plants. They are sealed with mud or cow dung.

Within the sorghum a distinction should be made between the red unpalatable varieties used for making beer with reasonable storing characteristics and the soft, palatable white varieties which are heavily attacked by insects. Groundnuts do not give any storage problem as long as they are unshelled.

Many vegetables are stored in calabashes after drying them. Sometimes they are cooked before drying and storing.

6.7 Labour

Due to the short rainy season a very high labour peak is observed immediately after the rains start. Cultivation, planting and weeding should be done in the first two months: usually from half December to half February. In this period the final yield of the major crops is determined. After this period only a few minor crops can be planted, notably sweet potatoes and cassava on normal rainfed fields and vegetables (tomatoes, spinach) and sugarcane in valley-bottoms with a high water table. As few people have an area in this valley bottoms the period March-April is fairly relaxed, watching the fields for birds/animals and thieves is the most important job. From the beginning of April people start to harvest some short term maize and the first groundnuts. At the end of April and beginning of May the harvest of groundnuts asks a lot of attention, while from the second part of May till July is busy with harvesting, transporting, threshing and winnowing the major cereals.

The division of labour between the sexes is the same as in many African societies: men are mainly responsible for the clearing and cultivation of the land and women for weeding and harvesting. Seeing the high labour peak this division is not strictly observed. Most of the time all do the same jobs, except winnowing which is a typical women's job. Planting is done by everybody. This looks a balanced division but in practice women are much more involved than men. Combined with the fact that women are the majority it means that they do perhaps 75% of all field work.

In the area as a whole there seems to be no labour shortage: all year round (also in the labour peak period) daily labourers are looking for jobs. This means that the land shortage is so acute that not all available labour can be used. This does not mean that individual farmers are not experiencing a labour shortage during a part of the year. Many farmers actually do but they do not have enough money to employ the unemployed labourers. The unemployed people seem to be a group of semi-landless people. They have not enough land to be self-sufficient, and to supplement their farm income they look for work in the wet season. Often they have to indebt themselves to get enough food during the last months before the harvest. After the harvest they have to pay back these debts and also for things like tax etc. they need to sell part of their harvest quickly. Many of them are in a vicious circle of poverty.

6.8 Yields

Yields differ a lot from year to year, but still can the average yield as presented in table 8 (next page) be used as an indicator for the productivity.

It is clear that the average yields are very low. When compared with data from 1981 to 1983 in Mundemu (AHT, 1984) the yield in 1990 was about the same and in 1991 it was considerably more. Is this enough to feed the population? To answer this question first the requirements must be quantified. In theory 210 kg of grains/cap./year are needed if every person eats 2.000 Kcal./day. However these estimates are based on western standards, and in practise many

Table 8: Yields per acre and per households of the most important food crops

		millet	sorghum	maize	g'nuts	bambara
acres/h.h (1991)		3.1	0.9	1.2	1.4	0.4
yield/acre:	1989/90	138	143	130	131	96
(kg)	1990/91	258	324	220	131	106
yield/	1989/90	428	128	156	183	38
h.h. (kg)	1990/91	800	292	264	183	42

Source: data from the MRTC-RRA (1991)

times a lower consumption is measured. In Mundemu the staple retention was between 130 to 200 kg/cap. in different situations (AHT, 1984). Partly this can also be explained by the large portion of children in the population who need less. On the other hand the feeding conditions in 1982/83 must have been far from optimal in Mundemu. So here a production of 200 kg of grains is put as the minimum reqnirement for (a more or less decent) survival. The visited farmers (who are better of than the average farmers) harvested in 1990 110 kg per household member of the main cereals and pulses. Perhaps this is supplemented till 150 kg by some sweet potatoes, cassava, cowpea, small stock etc. It is less than the minimum of 200 kg which means that either the income must be substantial supplemented with off-farm income or that people are underfed. Both was the case in 1990 in Mvumi division.

In 1991 the visited farmers estimated that they will get about 185 kg per capita of the main grains and pulses. If supplemented by the harvest of all minor crops it may be just enough. This is for somewhat wealthier families and it is only for pure subsistence; there is no room for selling or barter for things like soap, cloths, schoolfees, tax etc.etc. So also in this relatively good year off farm income is crucial and Mvumi is a net food importing area.

6.9 The economics of crop production

Table 9 on the next page presents the yields and the monetary value of the five most important crops in Mvumi (all 1991/92 prices).

The prices in table 9 are the prices immediately after the harvest because few farmers can wait with selling their harvest till the prices start to rise. The prices will usually more then double during the year, but the ratio between the different products is nearly the same all the time. The return in US $ in 1992 prices is between 0.1 and 0.15 per hour. However as the Tsh. dropped tremendously ever since, in current prices it is about 0.06 US $/hr.. These data are in line with Ruthenberg (1980) who gives returns between 0.06 and 0.16 US $/hour in similar situations.

Table 9: Some key-data on the yields of the most important crops

	b.millet	sorghum	maize	g'nuts	bambara
yield/acre (kg)	198	233	175	130	100
price/kg (Tsh)	42	42	40	67	50
hours/acre	297	294	213	260	210
return/hour	28	33	33	34	24

Source: data from MRTC-RRA (1991) and for labour inputs MDB (1986)

The returns per hour are worse for the most traditional food crops: b.millet and bambara nuts. This is however an unfair statement, specially for the millet as this is grown on the poorest soils. If maize would be grown there the return per hour would definitely be lower. The returns in kind is roughly 0.75 kg grain/hour.

It is surprising that the returns per hour for groundnuts are not higher than for sorghum and maize. First of all the 1991 season was specially bad for the groundnuts as it was a very short season, the average yield was exactly the same as in 1990 which was a bad year for all crops. In 1990 the returns per hour were higher for groundnuts than for cereals. Secondly also groundnuts are often cultivated on sandy soil where maize would fail. Other reasons for still growing it is that it's labour demands do not collide with that of the cereals and that it provides some food before the cereals are ready.

If the whole harvest is sold immediately after the harvest in 1991 the visited families would get about 66,000 Tsh. for the yield or 8.350 Tsh/capita (= 36 US $/cap.). In 1994 the total income is slightly more in Tsh., but far less in US$. In any case crop production does not yield enough for even a subsistence living so people must have other sources of income, f.e. beer brewing, salt making, trade and income from migrant labour (see also 3.5.1).

An exception should be made for the intensive gardening in the western part of the division. In sugarcane and tomato production the income can be fairly high although the data are somehow unclear (Minderhoud, 1993).

7 THE LIVESTOCK SYSTEM

7.1 Introduction

For the Wagogo cattle are of major importance both in terms of income and in terms of social status and cultural values. As described in chapter 5 the Mvumi division was destocked in 1986 as the animals were too detrimental to the environment. So although there is no extensive livestock production anymore in Mvumi it is still analyzed here in order to be complete and to be able to asses the impact of the destocking properly.

7.2 Extensive livestock keeping of before 1986

7.2.1 Size of the herd

Traditionally the average herd of the Wagogo consists of about 12-15 cows and the same number of small stock (mostly goats/some sheep). Table 10 shows the number and type of animals in Mvumi before the destocking.

Table 10: Number of ruminants removed by HADO in September 1986

ward	number of livestock keepers	number of cows	number of goats/sheep	number of donkeys	average number of LU/household
Makulu	250	3,584	4,379	175	15
Mission	343	7,100	5,147	256	20
Muungano	305	3,859	4,351	86	13
Handali	262	4,083	5,093	89	16
Igandu	288	5,642	3,670	210	18
Idifu	120	1,347	1,083	37	11
total	1,568	25,615	23,723	853	16

Source: office of the divisional secretary

The herd size was more or less the same as traditionally practised. As in most semi-arid areas the number of cows is roughly equal to that of sheep/-goats. HADO uses other figures which are not specific on villages: 30,991 cows, 33,754 goats/sheep and 1,174 donkeys. Their total number of LU is 31,746 compared to 25,322 in table 10. The data from HADO are an extrapolation of the data of the livestock census in 1984. As the census collided with the first tax on cows many people tried to hide their animals for the enumerators. So they shifted them from the villages which were still to be counted to others where they had already passed. Some people staid with some of their animals in the bush for a few nights. According to some farmers and a VEW who was around by that time, possibly 25% of the cows was hidden. More was not possible as it would be noticed by the enumerators by the size of the kraals and neighbours might treat them. This indicates that the number of livestock in 1986 was lower than in 1984, meaning that some animals were taken out of the area when people heard rumours about the destocking. People indeed confirm that some big herds moved already before the destocking.

Taking the figures from table 10, the stocking rate was 25,322 LU or 0.5 LU/capita. If the HADO figures are taken it was 0.7 LU/cap.. Considering the hiding of animals it could have been at the maximum 0.9 in 1984. In any case it is less than in the past (1.5-2 LU/capita) and the 1.8 LU/cap. in Mundemu (1982, pop. dens. 23 inh/km^2; AHT, 1984). It is also lower than the 1.1 LU/capita found by Christiansson (1981) in Ikowa in 1972 (with 32 inh/km^2).

The stocking rate was 2.9 ha per LU, equal to the carrying capacity as estimated in literature (Christianson, 1981). So there was just enough land to support all the animals, if all people would move out. But the population density was 63 inh./km^2 km, already on itself above the carrying capacity.

The 1,568 household who possessed livestock comprised 17% of all households. In the past 90% of the households used to have cows, and before the drought of the early fifties is was 60% (Ndorobo, 1973, cited by Hadjivayanis). In Mundemu in 1982 this was also only 24% (AHT,1984).

Although figures like these should always be treated with care they confirm that before 1986 also in Mvumi livestock was pushed out of the farming system, specially in the western part (see also 5.3). However this went not quick enough to prevent severe environmental degradation.

Some people in Mvumi still have cows, goats, sheep or donkeys. Of the 52 households interviewed during the RRA in 1991, 12 still owned livestock. This is 23% which is even more then the average before destocking, indicating that the selected farmers are bigger than average. On average they had 3 cows, while before the destocking the same families had 9 cows. The distribution of the cows was very screwed. Only 4 of them (=8%) had more then 6 cows and they owned 85% of all cows.

In 1991 during the RRA only 8 respondents (=15%) still had goats, on average 16 which is the same as the average flock size before destocking. Only one farmer still had a sheep. Nobody reported to have donkeys.

7.2.2 Herd composition

No data on herd composition are available from Mvumi, but some observation outside Mvumi support the assumption that it must not have differed much from the composition found in Mundemu in 1982/83 (AHT, 1984), which again is very similar to the one in Shinyanga as reported by Ruthenberg (1980) (see table 11 on the next page). In general the number of breeding bulls in the herd seems to be relatively high. For breeding purposes only 5% are needed which would leave room to increase the number of breeding cows. The high number can be explained by the fact that all farmers like to have a bull themselves and as the herds are relatively small the portion of bulls increases. As in Mvumi the herds were smaller than in Mundemu (where the average herd is 42 heads) it is likely that the percentage of breeding bulls is even higher.

Table 11: Herd composition of traditional herd in semi-arid Tanzania

percentages:	cows	heifers	calves	bulls	steers	oxen
Mundemu, 1982	48	7	20	11	11	3
Shinyanga, 1976	46	7	20	6	8	13

According to data in AHT (1984) the different categories of animals have the following liveweights: bulls and oxen 300 kg, cows 225 kg, heifers and steers 175 kg and calves 75 kg on average. The overall average weight per head is 195 kg, equal to 0.78 LU of 250 kg.

7.2.3 Grazing strategies

The Wagogo are widely recognized as skilful herdsmen. They have a thorough knowledge of grasses and other natural resources needed for the animals. Traditionally in the wet season the animals graze in the hills, after the harvest they eat crop residues and at the end of the dry season they use enclosed areas (in valley bottoms) where they had been forbidden before. There were communal enclosed areas ('luwindo') and privately owned smaller areas ('milaga'). The first were mostly valley bottoms which were either too wet or too heavy to cultivate. The area was marked and had a supervisor who decided on the exact date the animals could enter the area. He also protected it for trespassers. The 'milaga' could be anywhere; usually they were an extension of the field of the cattle owner (near his homestead) which was enclosed by putting thorny branches around it.

Before the destocking the animals of Mvumi were taken outside the area from December onwards. From the western part they went into Makang'wa division, from the eastern part into Mpwapwa and from around Handali into the Chilonwa division (north of the Morogoro road). In these areas they would first graze in the more hilly parts while later on they went into the valley bottoms. Normally a few people would unite their animals to get herds of 50-100 cows and an equal number of goats. A few milking cows and some of the smaller herds stayed behind.

Two boys of between 12-20 years herded the animals while two small boys (8-12 years) looked after the calves near the camp site. Every few days this team was changed by another team. The milk was immediately consumed by the boys or given away to local people. Some was processed into ghee and even some was simply spoiled as there was no market around.

The animals would come back to Mvumi between April and June and started to graze the crop residues. Traditionally they would then be shifted to the 'luwindo' or 'milaga' areas, but as these ceased to exist the problems with feeding them started from October onwards.

In all seasons the small calves stayed behind at the homestead. Sometimes they were simply locked up, but more often they grazed around the houses, watched by small children. In Mundemu 56% of the farmers mentioned to store some crop residues (AHT, 1984). Calves and milking cows are favoured when feeding this. Nineteen percent of the farmers do some supplementary feeding in Mundemu (AHT, 1984), probably this consists of some maizebran and some brewers waste .

7.2.4 Husbandry

Next to grazing strategies the most important husbandry activities were disease prevention and breeding. In Mundemu the mortality was 9% and the most important diseases must have been the same as in Mundemu: Anthrax, malnutrition, Rinderpest, East coast fever and Salmonellosis (AHT, 1984). In Shinyanga the mortality was 13%. The most important carriers of diseases are ticks.

In Mundemu 50% of the farmers claimed to treat their animals more or less regularly with drugs against worms and flukes. In Mvumi this seems very unlikely. Veterinary assistance can only be given by the VEW's of the GOT, but they do not have drugs. When they need drugs they have to get them from Dodoma town. Often the farmers find the prices too high and are afraid (sometimes rightly) that the VEW overcharges them. In the past the GOT used to provide drugs for dipping free of charge, but that became too expensive, ever since hardly any dipping takes place. These days the MRTC has a reasonable stock of drugs which are provided at a reasonable price.

An important breeding strategy is to remove breeding bulls from the herd at the end of the dry season. This prevents cows to become pregnant while they are in a too bad condition and it prevents them from calving in the dry season. In Mundemu 37% of the farmers said they selected the breeding bulls. The same 37% practised castration, but many time too late (up to 4 years old bulls were castrated; (AHT, 1984). Probably it could be done more if farmers would be able to share the remaining breeding bulls. The advantage gained might however be small compared to the trouble farmers expect from sharing a bull.

7.2.5 Labour

In Mundemu no data on labour were collected, but for Shinyanga some data are given. In total 4,596 hour were needed per herd of 25 LU. This is 184 hour per LU. However that is a mixture of child labour, wet and dry season labour etc. As shown above the situation is very complex: in the wet season herds are combined to reduce the supervision needed, sometimes children do the work etc. An estimate for Mvumi could be that per herd 10 hours per day are needed, so in total 3.650 hours per year or 228 hours per LU.

A common feature of the livestock system is the trustee-system. People with many cows prefer to divide their herd over several smaller herds. This reduces the risks of diseases, theft and droughts and makes it difficult for others to asses the wealth of the owner. So they give part of their animals to other people to look after. The herdsman is given the milk and the manure as a salary. All off spring is in principle for the owner of the animal. Only when somebody has been looking after many animals for a longer period he might be given an animal as a reward. As the salary is very low the trustee-system is not used much anymore.

7.2.6 Productivity

7.2.6.1 Introduction

No recorded data are available from Mvumi, so the data here are mostly taken from AHT (1984) on Wagogo in Mundemu in 1982/83 and from Ruthenberg (1980), quoting Pudsey on Wasukuma in Shinyanga in 1976. Most data are checked with a few farmers outside Mvumi (in neighbouring Makang'wa) and in discussions with people from Mvumi about the past.

The first aim of keeping cows is security, it offers a possibility to save money until it is really needed, f.e. for times of shortage of food, court cases or marriage. In Mundemu it was found that 30% of the transaction with cows was for marriage, 30% was sold and 40% died or got lost in another way. The sales were nearly always caused by food shortage. Very few animals were slaughtered for home consumption: both in Shinyanga and in Mundemu only 2%.

Despite their very important role in social live of the Wagogo, animals are also an investment of which the productivity can be estimated. In Mundemu the calving rate was 44% (so less than the 'normal' 50-60% which was observed in the other agro-ecological zones in Dodoma and in Shinyanga). The weaning rate was 39% (Shinyanga 43%) and the mortality rate 9% (less than 'normal' f.e. in Shinyanga is was 13%). The live off-take in Mundemu was 7% and in Shinyanga 10%. All in all this indicates a poor productivity, as will be seen below. Kusekwa (1994) gives a productivity of 4.5% market off take and another 3% of culls. The mortality among animals over 1 year is 10%.

7.2.6.2 Meat

For cows the total production in Mundemu can be taken as 25%: 7% live off-take, 9% mortality and 9% growth of the herd. In Shinyanga production was 23%: live offtake 10%, mortality 13% (while the herd seems to be stable).
The data of Kusekwa (1994) come to 7.5% live off take and a mortality of about 15%. Due to the severe overgrazing the production in Mvumi must have been somewhat lower. If it is assumed that the offtake in Mvumi was about 16% (8% live offtake and 8% mortalities consumed) and that the average carcass weight was respectively 69 kg and 53 kg (like in Shinyanga) then 250,000 kg/-year of cows meat was produced, or 9.8 kg/head which is equal to the 9.6 kg/head for the whole of semi-arid Africa as estimated by Jahnke (1984, cited in Traoré, 1991).

For goats and sheep the following coefficients are valid in Mundemu: live offtake 11%, mortality 10% herd growth 10%. For Shinyanga this is respectively 27% and 16% with a stable herd. If it is assumed that in Mvumi live-offtake was 20% and deads consumed was 10% and if the carcass weights of Shinyanga (6 and 10) are taken then the total meat production was 52,000 kg/year or 2.2 kg/head which is far less than the 3.5 kg quoted by Janhke (op.cit.) on the whole of semi-arid Africa. This must be caused by the very low carcass weight of live offtake in Shinyanga of only 6 kg, which gives a liveweight of only 12 kg (if a normal dressing percentage of 50% is taken). If this is corrected to be 10 kg (like the dead offtake weight and more in line with the estimated liveweight of the goats presently seen outside the Mvumi) then the total meat production would be 71,000 kg or 3 kg/head.

If it is assumed that about 25% of the total meat production was exported from the area, then people used to consume about 4.8 kg of meat per capita per year, or about 13 gram per day. With a protein content of 18% this is 2.4 gram of protein per day or about 6% of the daily requirements. In the most optimistic case this could be 10% if all dead animal are counted and the actual dressing percentage is higher as as much as possible from the animal is eaten. Clearly not everybody would get an equal portion and many (notably the poor) must have consumed near to nothing.

7.2.6.3 Milk

If 48% of the herd are breeding cows with a calving interval of 2 years (as the calving percentage in Mundemu was only 44%!) then every year 6,148 cows calf. Roughly two third (4,000) would calf in the wet season and the remaining (2,148) in the dry season.

Cows calving in the wet season would produce about 210 litres (an estimate based on discussions with farmers); those calving in the dry season would give 150 l. The total milk production would be 1.16 million litres per year. This is slightly less than the productivity in Shinyanga as reported by Ruthenberg (1980): 53 l/head/year or 1.32 million litres/year for Mvumi. Jahnke (1984, cited in Traoré, 1991) estimated a milk production of 66 l/head/year for the whole of semi-arid Africa. This would lead to a milk production in Mvumi of 1.69 million litres per year. In Mvumi this can not have been the case: the major draw back being the very long calving interval. An additional problem is that some milk was spoiled in remote camps with no market outlet (see par 7.1.3.).

If it is assumed that the total production was 1.25 l/year than per day 3,425 litres were available. Normally people used the evening milk (40%) for home consumption and the morning milk (60%) is sold. So for the cattle owners 0.15 l./day was available which is equal to 6 grams protein or 15% of the protein required. The daily amount sold to non-cattle owners was 2,055 litres or 0.05 l/capita. With a protein content of 4% this adds only 0.2 gram/day, less than 1% of the amount required. Considering that the distribution of milk must have been very skewed, only cattle owners and some richer families consumed milk in quantities large enough to contribute significantly to their health.

7.2.6.4 Manure

The amount of manure produced can be estimated as the total liveweight times the daily intake of 2% with a digestibility of 50%. This gives 23 thousand tons of manure per year. As a large part of the animals spent part of their time outside the area, the production inside Mvumi can be put to 80% of this, or 18.5 thousand tons. Of this, half would be dropped in the areas where the animals graze. If they spent half of their time on fields and the other half on grazing areas 4.6 thousand ton dropped in the fields and the same amount in the grazing areas. The remaining 9.2 thousand ton entered the kraals. As it was usually left there for long periods in which it was subsequently wetted and dried the total amount is reduced, probably until only half of the original amount is left (see Semoka et. al., 1983).

So 4.6 thousand ton was available for 1,568 households. This gives 3 ton per household. In Mundemu about 80% of the farmers having animals used manure, so 2.4 ton is actually applied on the fields. As per acre about 1 ton/year is needed 2.4 acres can be fertilized with FYM. As the bottleneck for the use of FYM is transport usually only the fields around the homestead receive FYM.

All other fields receive the 4.6 thousand tons which were dropped when they are grazed. This is 100 kg per acre. This is reasonable if one assumes that per acre 200 kg of grains are produced and an edible crop residue of 400 kg. Roughly 50% is turned into manure (50% is used as a source of energy for the animal), and of this again 50% is taken to the kraal.

How much extra grains will be produced as a result? Although the major effect of the livestock is on sustaining the organic matter of the soils, here the N-content will be used for an estimate. This is justified as N is the most limiting factor in crop production after water. The manure will in general be of low quality as it is usually very long and intensively exposed to sunshine and to subsequent wetting and drying. The N-content can be assumed to be 0.5%. As in total 8.3 thousand ton is applied this gives 41.500 kg of N. If each kg of N gives an extra production of 12 kg (see 6.5) this yields an extra 500 ton of grains or 10 kg/cap. Of this 40% is obtained by the non-cattle owners as the animals leave their droppings on the fields during grazing. The non-cattle owners (85% of the population) gain 5 kg of grains per year per capita and the cattle owners (15%) gain 41 kg/year/capita.

7.2.7 The economics of extensive livestock keeping

Per LU 50 litres of milk is produced and 13 kg of meat. With current prices this gives a gross income of 9,550 Tsh/LU/year. As 228 hours are worked for this the income per hour is 42 Tsh. If the return to the capital invested is taken to be 5% the income per hour is 36 Tsh./hr..

7.3 Zero-grazing

7.3.1 Introduction

As a compensation for the losses caused by the destocking in 1987 a Swedish mission suggested to start zero-grazing in the area. As HADO had nor the money nor the expertise to do so, nother partners were sought. In Mvumi first the Diocese of Central Tanganyika distributed three improved heifers (given by Heifer Project International), but it was only taken serious by the farmers when the MRTC brought the second group of 12 improved heifers in 1991. From 1992 onwards, the use of local cows was also actively encouraged.

Between 1991 and 1994, 53 farmers received a F1-heifer free of charge on the following conditions:

- two members of the household must follow a training; at least one of them must be female;
- a durable stable must be built;
- two acre of fodder must be planted (later this was replaced by the requirement of a store for dry season fodder);
- the first female offspring must be given back to the MRTC after 6 months and in case the heifer is pregnant also the third one;
- in case it is not well taken care of the MRTC will take it back.

Table 12 shows the expansion of zero-grazing in the last 3 years (1991-1994).

Table 12 The expansion of zero-grazing since 1991

date	zero-grazing farmers	improved cows which have calved	improved heifers and female calves	local cows	total number of animals	villages with a serving bull
1-7-91	22	2	16	4	27	2
1-7-92	62	29	27	16	104	4
1-7-93	90	35	37	32	174	5
1-7-94	131	51	54	45	210	6

Source: for 1991-1993 MRTC half year reports, for 1994 MRTC monitoring system

The table shows that the total number of farmers and the number of both local and improved cows is steadily increasing. In the same period 20 farmers stopped with zero-grazing: 3 cows were taken back by the MRTC as the management was not good, 3 had an improved cow but stopped themselves, 14 stopped who had local cows. Of them 3 were stopped by HADO/MRTC as their stables were not appropriate and 11 stopped for other reasons (mostly they found it too much work often as a result of a change in family composition).

In the whole division in 1990 about 3,000 l. of milk was produced. In 1991 this was 9,000 and in 1992 it jumped to 43.000. As can be seen from the table the number of cows did not increase much in 1993 so the milk production did not rise much: it came to 53,000 litres (all data from the MRTC monitoring system). As can be seen in the table the number of heifers is increasing quickly now so in 1994 again an important rise in milk production is expected, possibly up to 75,000 litres.

Until June 1994 21 farmers have given a female calf back to the MRTC who gave it to another farmer. In May 1994 the first cow born in Mvumi gave birth. In March 1993 78 farmers practising zero grazing were interviewed to get a detailed insight in the management of the cows. The results have been published extensively elsewhere (Holtland 1993) and are only summarised here while some additional information is given when appropriate.

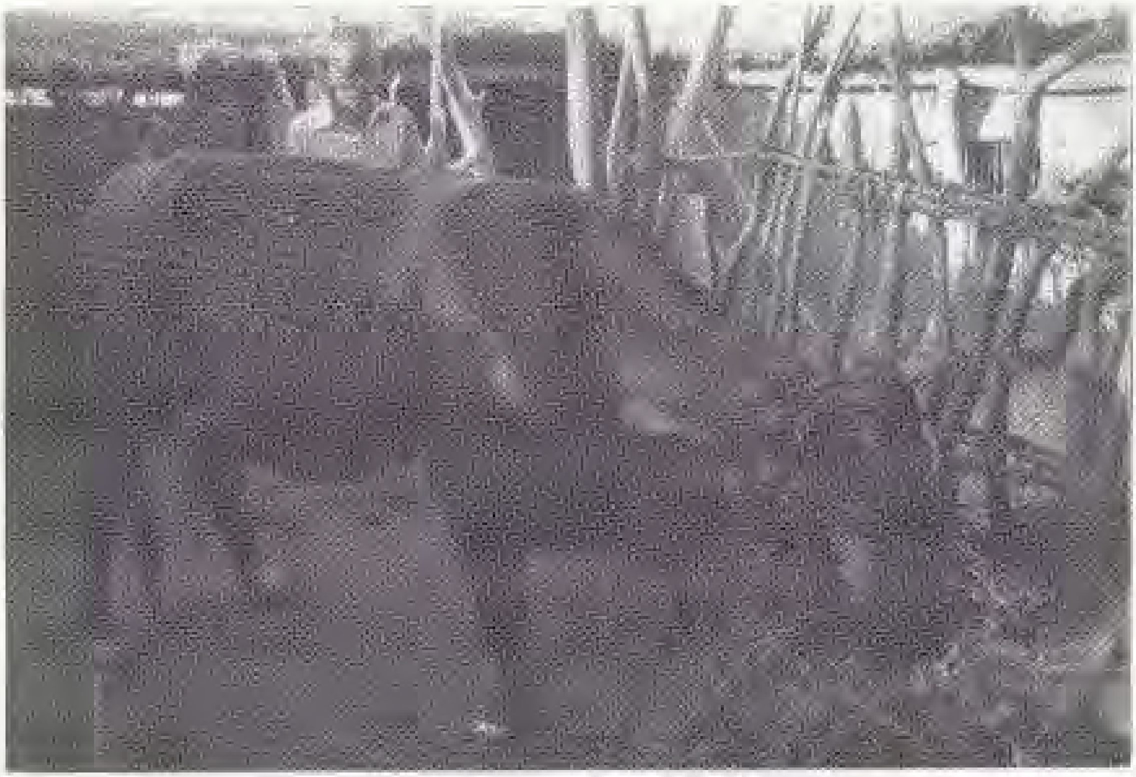

Figure 13 A proud farmer with his cow, producing over 10 l./day

7.3.2 The households practising zero-grazing

The target group of the MRTC are the 'average' farmers, but as in the first year the benefits of zero-grazing were still unclear and the risks seemed to be high, better-of farmers were selected. After seeing that the risks were rather low from the second year onwards the selection of beneficiaries was more rigid oriented towards average or poor households. Women (specially those heading households) were encouraged to apply. In 1992 and 1993 about half of the heifers were given to women, of whom 50% are head of their household. They perform as well as male heads of households. In 1994 5 of the 13 cows were given to women, 2 being female heads of households. In Holtland (1993) it was shown that it is possible for a poor household to run a zero-grazing unit as the initial investments are low.

7.3.3 The management of zero-grazing cows

Housing
Due to the pleasant climate (see 4.1) the cows experience only moderate heat stress during short periods of the day. During the participatory training of the second group of farmers a simple model stable was designed based on the experiences of the first group of farmers (with their stables of all kind of designs) and the demonstration stable of the MRTC.

It consists of a sleeping place (2 or 3 cubicles), an open space (8 m^2) and a shaded feeding place (6 m^2). It requires only local materials. Ever since all farmers follow more or less this design.

Nearly all farmers only use local materials for their stable. If all materials and the necessary labour were bought it would costs 25-30.000 Tsh. but often farmers only use their own labour (cutting poles, grass etc.) and/or they make use of existing structures.

Figure 14 A stable for a local cow made from local materials

Health
Nearly all animals make a healthy impression. Health problems are few as there are hardly any ticks. All 52 improved animals together were sprayed 47 times. Of the 26 farmers having local cows only 3 had sprayed them. Out of the 78 farmers only in one case ticks were found. Some mastitis occurs as a result of poor milking techniques.

In the 4 seasons 5 cows have died. Two when they gave birth (one calf survived), 2 had swallowed a sharp object and 1 had an abscess in its heart. Non died of a disease. In the same period also 6 calves died. This gives an overall mortality rate of 6%, a very low figure for improved cows in Tanzania.

Water
Per cow 1.5 to 2 debes (=bucket of 20 l.) of water is needed per day. For a local cow 20 litres is enough. In the dry season also watermelons are fed to meet the cows water requirements. Sometimes these are bought from others and some farmers started to grow more watermelons to meet their own demand.

Fodder
In the wet season (Jan-April) the most important species are local grasses and legumes. Most prominent are Dactyloctenium aegyptium (locally 'Ihungo') which grows mostly on fallow plots and Dactylon spp. ('Ndilo'). Others are Rottboellia exaltata ('Mbugumbugu') and Rynchelitrum repens ('Ng'ame'). Important local legumes are a.o. Crotelaria sp. ('Nghazi'), Desmodium spp. ('tengulaulili') Clitoria tennatea ('fundo-fundo'). All are mostly found in valley bottoms and fallow fields. Also important is Elephant grass from sand rivers (planted by HADO or farmers).

From May onwards people start to harvest their food crops and groundnut haulms become the most important fodder. Of secondary importance are maize stover, Dactylon spp. and Elephant grass. Of tertiary importance are crop residues of lab-lab and sorghum as well as watermelons and pods of Acacia tortilis and A. albida. The same species stay prominent until the next rains. When the rains start Dactylon spp. are the first to sprout again.

In general farmers try to increase the quality of the feed by offering large amounts of biomass from which the animals select the most digestible parts. The best farmers also offer the animals some green foliage every day. For this they use mostly Leuceana, sweet potato vines and Elephant grass from sand rivers.

So generally in the wet season only natural grasses and legumes from fallow fields and valley bottoms are used and in the dry season mostly crop residues supplemented with small quantities of other feeds. So the pre-condition of HADO/MRTC to grow one acre of fodder was inappropriate. Reasons for this are:
- not enough seeds of improved species are available;
- due to the high population pressure no land is available for fodder production;
- establishing a fodder plot in the harsh conditions of Mvumi is very difficult, and even if well established the production is very low;
- establishing a fodder plot requires a lot of labour in the peak period of crop production, when opportunity costs of labour are high.

It must be concluded that growing fodder is not economically viable as the product has to compete with easy available natural grasses and crop residues. Therefore the pre-condition of a fodder plot was dropped. This will not result in erosion problems because the vast majority of the natural grasses are of very low quality and grow on far away hills where they prevent erosion. To cut these grasses will not be economically viable and even if they would be cut the basal stems and roots would sprout again.

Concentrates
All farmers use their home made maize bran and brewers waste. Only 29% sometimes buys extra from others. When available 1 - 2 kg is given per day. Al-

though the price of maize bran is quite high (it is also used for pigs and sometimes for beer making) using some more is economically viable. Specially when it is used before calving and in the beginning of the lactation. It appears that many farmers do not have cash to invest in the feeding of their cows. Possibly also the unsure market for milk discourages some of them.

Supplements like minerals are hardly used. Also no signs of mineral deficiencies were noted. As the pH of the soils in the area is high no problems are expected in the future.

Milking
Milking is often done by female members of the households. Often the milking technique is poor: they milk only one teat at a go using the stripping technique. It might be that sometimes the full potential of the cow is not reached as in the beginning of the lactation milking takes too long.

Calf rearing
Until 1993 the calves were bucket or bottle fed (to get more exact data on milk production) but after that restricted suckling was advocated. In general the calves get 2 and 2.5 l./day in the first two months and then it gradually drops to weaning after 4 months. No particular health problems occur, some diarrhoea is observed but no losses occurred. After weaning worms are found but also not at an alarming rate.

Marketing
The MRTC encouraged the farmers to form a 'zero-grazing group' in each village. In Mvumi Mission and M. Makulu they have worked reasonably until now. The farmers decided to put the milkprice to 100 Tsh./litre. Generally people only sell about 2 l./day, or about 600 l./lactation. Some sell up to 4-6 l./-day. Until now only now and then some farmers had a marketing problem but from May 1994 onwards it seems the problem is becoming bigger, both in M. Mission and in M. makulu about 30 litres per day has no market.

A good market could be found in Dodoma (40 km). The price is higher (130 Tsh./l.) and there is daily transport to town. As electricity for cooling and daily transport opportunities are available in both M. mission and M. makulu it should be possible to market the milk in town.

Handling manure
Cows are ideal animals to convert useless roughage in valuable milk and manure. This manure should be returned to the soil to sustain the fertility of it. In practice this ideal is still very far away in Mvumi, specially for the most limiting nutrient nitrogen. First of all nearly all N in the urine gets lost and part of the N in the manure as the floor of the stable is just compacted soil on which the N quickly disappears due to the high temperature, wind speed and radiation. Secondly the manure is just piled outside together with the discarded fodder. Due to the dry climate composting goes slowly and when the manure is applied it is often not worked under properly.

Most farmers apply it on their homestead fields and the results were very visible. Some use it for intensive gardening or grape production.

Fertility of the cows

The survey in 1993 showed that the age at first calving of the improved cows varied between 30 and 45 months, with an average of 36 months. In 29 cases a reliable estimate of a calving interval could be made. The average was 17 months, but a large variation was observed. In 8 cases it was over 20 months. Together with some heifers who delayed for their first calving one third of the cows has fertility problems. This is partly caused by a lack of a well functioning monitoring system (both on farm and project level) and partly because the MRTC has (unconsciously) been too optimistic on the local knowledge about the fertility of cows. It is now clear that although Wagogo are agro-pastoralist, they do not know when, how long and how often a cow is on heat.

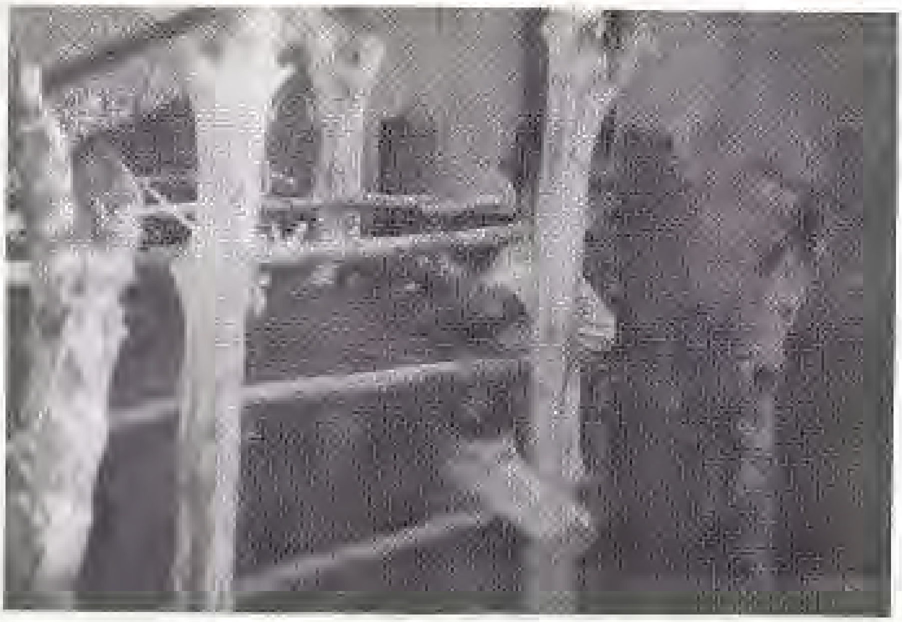

Figure 15 Mr. P. Mnyangulu, MRTC coordinator, doing a pregnancy diagnosis

Breeding policy

Until now the MRTC has been working with different crossbreeds: Ayrshire/TSZ, Friesian/TSZ and Mwpapwa/TSZ from a DAFCO farm in Morogoro and Boran/Friesians from Kenya. The last one performed better then the others. Partly because they were better taken care of before they came to Mvumi and partly because they are bigger.

The often hot debated question on how much exotic blood should be used is not yet answered, but at the moment nothing indicates that 75% exotic blood would not be possible. On one side it is doubtful whether this high percentage as such would bring higher yields as long as the feeding of the animals is not improved. On the other side, animals with more exotic blood respond better to any improvement so they might be a stimulus for better management. As no differences were found between Ayrshire and Friesian crosses for practical reasons (availability) Friesian bulls are used.

7.3.4 Production

The cows produce milk, meat and manure. Here the milk production is analyzed. The data shown in the following figure are from the records which MRTC farmers are requested to keep.

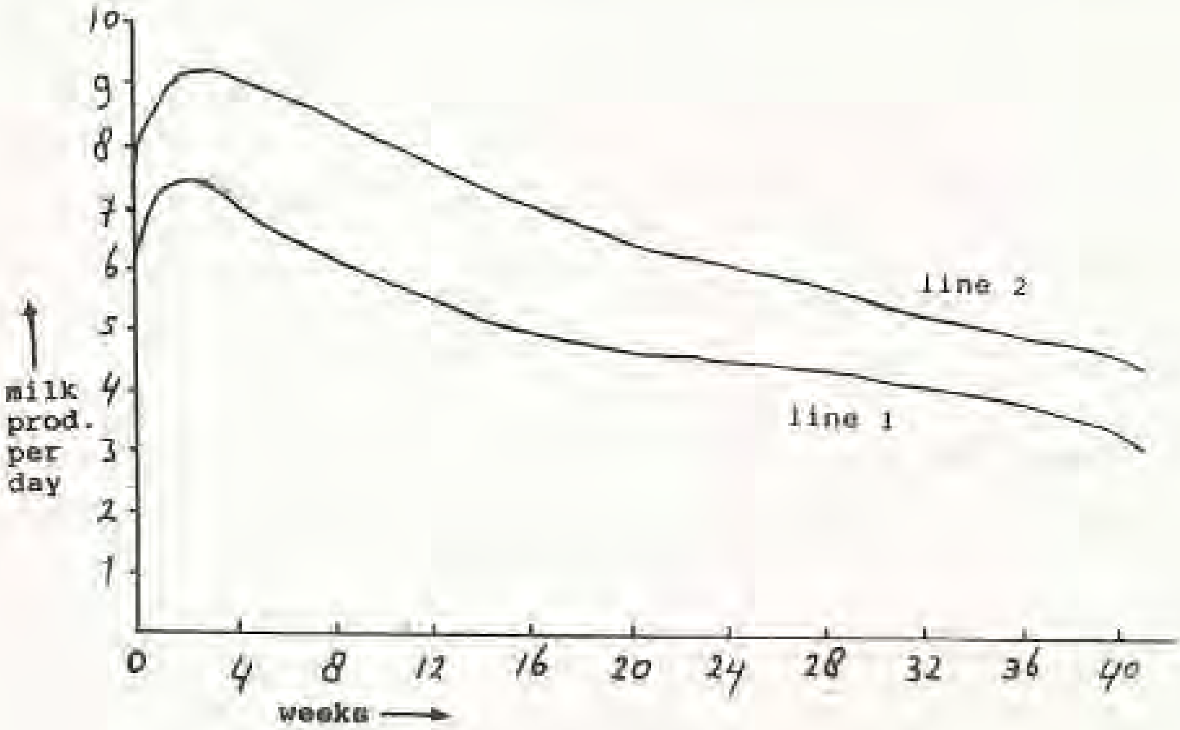

Figure 16 The lactation curve of improved cows

The animals are divided in 2 groups: the mixture of F1-heifers from the DAFCO farm and the Friesian/Boran crosses from Kenya. The first group consists of 20 heifers. Two of them died, 3 produced very little (local and Mpwapwa blood) and one had unclear records. The data of remaining 14 are shown in line 1. Their total production in a normal lactation of 305 days is 1,452 litres. As around 250 litres are given to the calf, 1,200 litres can be consumed or sold. Many times the intercalving period is 18 months. In the last months the production is 2 l./ day. This makes the total production in 1.5 year about 1,800, or 1,550 litres for sale or consumption.

In their second lactation the cows are expected to produced 15% more (Holtland, 1993). This leads to a total production of about 2.080 l. of which 1.800 can be sold/consumed.

The second group of animals are the Friesian/Boran crosses from Kenya. Their production can be seen in line 2 (based on 6 animals only, as some gave birth before they came to the farmers, their data were not used). They gave 1.923

l. in the first 305 days of the lactation. This is 32% more than the first group. Their production tends to drop to 3 litres per day when the lactation is prolonged. This gives a yield of 2.470 litres in 1.5 years, of which 2.200 can be sold/consumed. Several of them started their second lactation and most had a peak production of over 10 l./day.

The shape of the curve is reasonably in both cases. The peak yield is reached quite early but the persistency is good. It takes 40 weeks before the production has dropped below half the peak yield (= average of the first 6 weeks).

Although the number of cows involved is too low to come to definite conclusions the variability in the data is rather low so the trends identified here are not likely to be changed when more data become available. Also the still un-analysed data from 1994 indicate that the lactation curves are similar to the above. At the moment too few data are available to identify a marked seasonal influence.

Not enough data are available for local cows, but most produce between 1.5 and 3 litres/day. Per lactation of 1.5 year they might reach 600 litres.

7.3.5 Economics

7.3.5.1 Capital investments

Cows
At the moment an in calf F1 heifer costs 150.000 Tsh. A local cow costs about 25.000 Tsh. As mentioned in par. 2.1 a completely new stable would cost between 25 and 30.000 Tsh., but most farmers only spend 5.000 or less cash on it and do the work involved themselves.

Running costs
For the maintenance of the stable about 1.000 Tsh. is needed per year. Of the 52 farmers interviewed 51 spent less than 1.000 Tsh./year on health services. Many people without an employee spend some money (2.500- 4.000 Tsh./year) on buying fodder every now and then.

Paid labour
All people who bought an improved cow have a boy/young man working for them. They pay 2.500 Tsh. per month plus food and basic needs. They are responsible for all the work on the cows. Of the 48 MRTC farmers interviewed 9 had an employee. Mostly they pay 1.500 to 2.500 for bringing only water or fodder. Some pay 4.000 for someone who does all the work. Usually they also get food and basic needs. Frequently employees run away after some time, because of the low salary and/or the bad labour conditions. Nobody having local cows has an employee.

7.3.5.2 Own labour

During the survey also the labour requirements were asked. This was done by starting from the then actual situation and then let farmers extrapolate from this to the other months of the year via lines drawn on the ground (the length of the line indicating the amount of time spend on the cow). In

Nov/Dec 1993, in March 1994 and in May/June 1994 these values were checked by an enumerator who staid with the households for a day and recorded what they were doing. In general it is very hard to identify the exact labour requirements. If someone takes 110 minutes to bring milk to a customer, to do some small shopping and fetch a bucket of water which is partly given to the cow, how much should be attributed to the cow? And what to do if a child stays at home just to watch the cow?

Despite these problems the data from the enumerator were remarkably well in line with the estimates made by the farmers and the present author (Holtland, 1993). The only major difference is the time needed for collecting water at the end of the dry season. This proved to be far less than thought. Possibly through the use of watermelons.

The next table shows the time allocated to the different jobs during the months of the year. The estimates are a modification from the one in Holtland (1993) based on the new data from the enumerator.

Table 13 Labor requirements for a zero-grazing unit (one cow and a calf) in minutes per day

	jan/feb	mar/apr	may/jun	jul/aug	sep/oct	nov/dec
fodder	106	94	86	118	153	178
water	38	30	39	46	54	60
feeding/cleaning	47	47	47	47	47	47
milking/marketing	88	88	88	88	88	88
total	279	259	260	299	343	373

The table shows that the day to day activities of cleaning and feeding are important components of the work and are constant over the year. Of course small differences were found in the data of the numerator but the variation was very small over the year (less than 10%) so is was decided to take it to be constant. If a cow is in milk also the milking and marketing takes the same amount of time over the year.

On average 303 minutes per day are spent, or 5 hours. This is 1.825 hours per year, about 10% less then previously estimated.

7.3.5.3 Economic viability

Based on the data from the survey in 1993 the returns per hours were calculated to be about 50 Tsh. per hour if a long time perspective (10 years) is used and the cow was obtained via the MRTC system of passing on the gift (Holtland 1993). If a cow was bought commercially for 200.000 Tsh. and a return to the capital of 10% per year was used and the hours in the peak season (Jan/Febr.) were assumed to costs 70 Tsh./hr, it still gave a return of 30 Tsh./hour. As the only change in these data is the labour requirements (which are actually slightly less than previously estimated) these data are still valid.

All these data stem from M. mission. In other villages water might be more difficult to obtain but fodder usually more easy. Also the opportunity costs for labour are cheaper in the other villages. So economically there seems no problem as long as a market can be found for the milk.

7.3.6 Division of labour and income in the households

In all cases building the stable is done by the male members of the household. Female heads of households get some assistance from others. In 79% of the households the first responsible for the collection of water is female. In general several members of the household are involved in collecting fodder. Most of the work is done by women, also in male headed households. Children (10-15 years) are actively involved. Only a few men do also particpate.

A lion share of the marketing is done by children. This bringing of the milk to the customer consist of 18% of all the time spent on zero-grazing.

Traditionally the Wagogo women have a major say in the use of the milk. In how far this is still the case with zero-grazing is hard to say, as farmers often lie when this issue is raised. Edwards (1992) found that women feel that they have more control over the (benefits of) a cow on zero-grazing than over the traditional herd. So it seems that the male head of the family gives his wife enough benefits to keep her motivated enough to take care of it. When this is not the case the condition of the cow worsens, milk production drops etc. This happened twice with serious results (the cow was taken by the MRTC). Problems often arise in polygamous families or when men leave their wife.

7.3.7 Carrying capacity for zero-grazing

If we assume that the cows are fed natural grasses for 5 months, in the remaining 7 months crop residues are the major source of fodder. The stover of groundnut, maize and sorghum are best suited for this (with a TDN of 60, 57 and 50 and a CP of 10, 6 and 5 resp.; Chamberlain 1989:61). A lactating cow of 400 kg needs about 15 kg/day of this stover (with some supplementation of maizebran/brewers waste and green foliage) to produce up to 8 litres/day. So in 7 months 3.200 kg is needed per cow.

As on average a farmer has 1 acre of groundnuts, 1 of sorghum and 1 of maize, the total available fodder is 1.125 kg per household (the grainyield is 250 kg/acre and the useful residue is 1-2 times as much). So when all crop residues in the area are systematically collected one third of the families can have a zero-grazing cow. As some farmers will keep more than one animal (the max. allowed is 3) 15% of the households can keep cows, or the same number of households which had cows before the destocking.

These households would have in total about 3.500 animals of which 2.000 can produce 1.500 l./lactation of 1.5 year (the remaining are calves and bulls). This makes 2 million litres per year, even more than the estimated milk production of before destocking (7.2). It represents a value of 200 million Tsh./year. This gives an increase in the income per capita of 15-20% and a doubling of the income of the households involved. In total about 2.000 people will be employed, taking care of the animals.

7.3.8 Conclusion

Although zero-grazing is a new practice in Mvumi, it is well established after four years. So as such it can no longer be considered an innovation, that is why it is described here as part of the existing farming system and not in chapter 10 as an innovation. Still it is good to give a short conclusion about the introduction of zero-grazing in Mvumi, as to compare it with the innovation mentioned in chapter 10.

Ecologically the cows make an optimal use of the available biomass in the area which would otherwise be burnt. The biomass on the hills which is critical in terms of erosion prevention is not used.

Economically the cows make it possible for the farmers to use their surplus labour in the dry season at a very attractive income per hour, despite the labour competition between the cow and crops in the beginning of the dry season.

In the future it is possible that as many households as before the destocking will have cows: 15%. This time they will practise zero-grazing. The total amount of milk produced can be at least the same as before.

So zero-grazing in destocked semi-arid Mvumi is ecologically sound and economically attractive.

In the near future the system can still be improved by using local resources. In the long run carefully selected external inputs are needed to make an even better use of the available biomass (see 10.3).

7.4 The destocking

7.4.1 Introduction

Although erosion has been a permanent feature of the farming system in Mvumi it became so bad that in 1986 the area was destocked. The operation was prepared and implemented by HADO (Hifadhi Ardhi Dodoma), a project of the ministry of natural resources. It was advised to destock only small areas or at the maximum half the area (HADO masterplan 1986-1996), but for practical reasons (easy control) it was decided to take the whole division. As we now have a detailed picture of the livestock system before and after the destocking, the destocking in its broadest sense is dicussed here.

First and foremost the destocking was a drama to the local population:

> "We first took our herd (60 heads) to Mlowa, near to the area where we used to go in the wet season, but there were not enough grasses. So we went on to Uzunguni, where we also hided them during the 1984 census. We went together with the herd of my uncle (70 heads) and we staid there from Dec. 1986 to June 1987. There was a lot of grasses, but the water was too salt. The goats of my uncle died, sometimes nearly daily. Of the 60 goats only 5 remained. Of our 60 cows only 40 survived. So we had to take them to Mpunguzi, where the stealing started. My nephew used 10 to marry. Others were stolen. We got tired of taking care of them so far away. When there were only 10 left we took them to Fufu, again near to the area were we used to take them in the wet season. Later we sold 2 and again later another 3, so now there are only 5 left."

7.4.2 Problems caused by destocking

7.4.2.1 Loss of animals/capital

Some livestock keepers moved with their cows to other areas. Most of them however sent their herd (sometimes with a member of the family) to other villages (just) outside the division. This worked out bad: many cows died or were stolen. The death causes could be too salt water, eating poisonous plants or bad management in general (diseases, malnutrition etc.). The theft could be done by strangers but also by relatives who would pretend that they were stolen, died or ran away.

It proved very difficult for farmers to control their herds far away and to get any benefit from them. So reluctantly, and often too late, they followed the advice of HADO to sell their animals.

> "My father had about 90 cows by the time HADO came. We took them to Kongwa, but they started dying. Foam came out of their noses. We made another camp and another. We staid at four different places but they kept dying. In 1989 only 30 were left. I had a cousin in Dodoma town who could buy a milling machine for 100.000 Tsh. So I asked my father to sell some cows so that we could get that mill here in Chanhumba. My father consulted his brother who advised him not to start this 'mambo ya uhuni' (= things of traitors). From that moment on he refused to sell the cows and now they have all died, including the 3 of me."

A rough estimate, is that only one third of the cows is still alive and less then this of the goats/sheep. Of the others, one third was sold and one third was stolen or died.

7.4.2.2 The loss of milk, meat and manure

Many people complain about these losses after the destocking. In par. 7.2 estimates of the amount of these products produces before the destocking are given. In 7.3 it is calculated that in the long run as much milk can be produced by zero-grazed cows as before, provided marketing is possible.

Although many people did hardly consume meat or milk before the destocking, this is not to say that the lack of milk is no problem because some people consumed reasonable amounts of it and the mere availability made it possible for others to buy it on an ad hoc base. For example when people are ill and for small children who were weaned.

To appreciate the role of milk for children some background information is needed (mostly taken from Anon. 1994). Wagogo children are breastfed until they are one to one and a half year old. Before that they are slowly getting used to other food. If however the mother gets pregnant before the child is weaned in this natural slow process, it is weaned suddenly. In both cases the children are weaned by using 'nhili', a thin porridge of millet. In the past sometimes milk or sour milk was used as a base for the porridge. After destocking this last option was not available anymore. So it might have increased malnutrition in weaning children to some extend. Indeed presently the rate of severe malnutrition in Mvumi seems to be higher than outside the area (according to several resource persons). There are also indications that shortly after the destocking child mortality went up (Chilangane, pers. comm.). However the higher rates of malnutrition may also be caused by a higher population density which results in poor feeding. Also the increased workload of women makes it more difficult for them to prepare the traditional weaning food based on a fermented porridge ('ubaga we zaliko'). Also the disappearence of the taboo for husbands to sleep with their wives for several month after she has delivered reduces the time between pregnancies and makes sudden weaning and related malnutrition problems more likely. These and other factor about beliefs and practices about breastfeeding as described in Anon. (1994) make it very difficult to assess whether malnutrition has increased due to the destocking. It is possible that it did but it would need more research to be sure.

After the destocking some cows are brought in from outside for slaughter but not enough to compensate for the loss. A rough estimate of the meat consumption in the division at the moment is 100.000 kg cow meat per year. The price of meat in Mvumi these days is the same as outside the division.

A way to increase the availability of meat is keeping pigs. Specially in the villages bordering Mpwapwa district (Idifu, Nghaheleze, Igandu) farmers started this. At the moment it is estimated that there are 500 of them. If they have a carcass weight of 50 kg (liveweight of 75 kg), in total 6.000 pigs need to be slaughtered yearly to compensate for the loss of meat after the destocking. At the moment the number of pigs is still increasing and in some villages farmers hardly started. A rough estimate is that about 2,000 pigs can be kept in the area.

On the side of the lack of manure it is remarkable that farmers claim that after the destocking the soil fertility has increased. A more detailed description of the N-cycle with and without ruminants can explain this. The numberous cows and goats converted the bulky low quality crop residues and natural vegetation into FYM. Technically they did this not very efficiently, as can be seen in the following model calculation which is mainly based on data from the PPS (1982) report. Of all N taken up, 5% is retained in the body of the animal, 50% is excreted in urine and 45% in the feaces. Of all N in the urine 75% volutates, half of the remaining 25% stays in the field and half is taken to the kraal. Of the 45% in the feces only 10% volutates and again the remaining is equally divided between the field and the kraal. So in the field only 26% (6% via urine and 20% via faeces) of the N remains and another 26% is taken to the kraal, where again large losses occur.

Since the destocking farmers simply burn the crop residue and the natural vegetation every year. The N recycled in this way is even more than above (most data again from the PPS (1982) report). Of all dry matter left in the field about 40% is returned directly to the soil by the soil fauna without much losses, let us say 10% (PPS (1982) and Skerman, (1977)). Of the remaining 60%, 25% gets lost via volatilization of NH_3. As the remaining 45% is burned at the end of the dry season 80% is lost. So of the total N in the biomass 45% returns to the soil and 55% gets lost via burning (36%) and volatization (19%).

Of the total organic matter also about 50% is incorporated in the soil by the soil fauna. With grazing animals this is about the same, as 50% of the organic matter is used as fuel for the animals and the losses in the other 50% (the manure) due to micobiological activities will be the same (or even more) as those occuring in the field when crop residues are incorporated.

Here we have the key to understanding why soil fertility did not drop after the destocking, but rather increased: the organic matter and N added to the fields is at least the same (and possibly more) after the destocking while the negative effects of trampling and wind- and water erosion are reduced.

The 3.500 animals which could be held under zero-grazing could bring back about 15% of the manure available before the destocking.

7.4.2.3 Loss of saving possibilities

In many farming system in semi-arid areas like Mvumi the major function of livestock is its banking function. People invest in a large herd as a saving account. In times of trouble the animals can be sold or exchanged for grains or other food. In this sense the destocking exposed the population of Mvumi to higher risks: when the crops fail they have nothing to sell.

However some remarks are needed here. First, still one third of the herd is left and functions as a saving account. Secondly pigs are used for the same purpose, with the additional advantage of having a quicker turn over.

7.4.2.4 Non agricultural losses

The loss of run off. As all the water infiltrates in the hills the sand rivers hardly carry and store any water. This means that in some areas water has become more scarce and in many places the possibilities for growing sweet potatoes in the sand rivers have disappeared. In other places the availability of water has increased as a result of a higher ground water table. This is f.e. the case in the valley near Mvumi mission where now a lot of sugarcane, sweet potatoes, tomatoes and vegetables are grown. Whether the total balance is positive or negative is unknown.

In a few places the rise in the ground water table resulted in field to be come too salty (in general this was more than compensated by new fields becoming available as they were no longer used as grazing areas).

It seems that the incendence of malaria has increased after the destocking specially in the western part of the divison, more specifically in Mvumi mission. The reason is that the many grasses give ample place for the musquito's to breed, specially the malaria musquito Anopheles which lays eggs in grasses. Many people claim that not only the number of musquitos increased but that they are also more troublesome. In the past they would go to the cows in the kraal, but now they all come inside the houses. In this way many people are forces to sleep outside for the whole night. As with the problem of malnutrition it is difficult to seperate the effect of population density as such and poverty, malnutrition etc. on malaria from this effect of the destocking. However it seems likely that there is a relation (as people claim) and more research would be needed.

7.4.2.5 The total economic losses

If we try to calculate the total amount of money lost by the inhabitants of the area, we can only make a rough estimates.

Loss of capital
If it is assumed that one third of the cows (about 8,000) died due to the destocking, and half of the goats/sheep (12,500) and that the average current (1994) price is resp. 25.000 and 5.000 Tsh. the total loss would be resp. 200 million and 62 million Tsh.. In total this is a loss of 5,400 Tsh./capita. If spread over a period of the first 4 years (1986-1990) it is 1,350 Tsh/capita/year, or about 3 US$, or 3% of the Gross production per capita. For the 1,568 owners of livestock the loss was over 160,000 Tsh., or 42,000 Tsh/year. With 6 members per household this is 7,000 Tsh./year or 14 US$. If the income of livestcok owners is 2.5 times as much as average (see table 1) this is equal to about 6% of their Gross production per capita. This is a severe loss, specially as possibly half of the losses occured in the first year.

Loss of income
The total annual milk production of 1.25 million litres represents a value of 125 million shillings, and the meat production of 321.000 kg has a value of 112 million shillings. As at the moment only one third of the animals are remaining, two third of this income is lost. This is 158 million or 3,260 Tsh. per capita, 6 US$ or 6% of the Gross production per capita.

The livestock owners lost 100.000 Tsh. of income per year per household. If it is assumed that their income was 2.5 times as much as the average (see table 1) and that they had 6 members per household, they lost 13% of their income. This is in average years, in bad years it will be much higher (see also 3.5.1.).

7.4.3 The benefits of destocking

7.4.3.1 Qualitative assesment

By the time of destocking the main aim was to stop further land degradation and to reclaim barren areas. Any visitor coming to the Mvumi division can see that these aims are achieved nearly completely. Even places which seemed to have been degraded irreversible are covered by some vegetation now. On the other hand the soils are not yet recovered. As is stressed by Shishira and Payton (1994) soil formation takes a very long time and re-introduction of livestock because the grasses have come back would lead to the same disasters as before the destocking within a few years.

Another matter is how farmers are perceiving the destocking. During the RRA in 1991 farmers were asked about this. The answers must be treated carefully because farmers may have thought that a positive answer was more appreciated by the team, because usually outsiders were more in favor of destocking then the farmers themselves. All farmers without exception were positive about the results of the destocking and many said that they first were against it. Many claim: "now we know the profit of destocking". Some said they knew other people who would like the animals to come back.

Asked about the changes which occurred after the destocking, nearly everybody mentioned the lack of either milk, manure and/or meat. It is remarkable that no farmer mentioned the function of livestock as a saving possibility and as a asset against dry periods.

On the positive side of the balance many different aspect were mentioned which can all be grouped into the following statements (text between brackets are comments, not quotations of the farmers):
- less soil erosion and gully formation, even most of the existing gullies disappeared;
- more grasses and trees;
- more land available for crop production;
- more crops can be grown in the dry season, particularly sweet potatoes and cassava which are not eaten by goats and cows anymore;
- more vegetables can be collected during the whole dry season;
- soils are softer: no trampling, more org.matter;
- higher fertility of the soil;
- more crops can be grown on different soils (f.e. due to the increased org. matter content and the increased fertility maize can be grown on a field which in the past could only yield millet);
- higher yields per acre;
- more water available in dry season;
- more bees and honey due to the increased number of flowers;
- less windy (also less dusty winds);
- more rainfall as trees attract water (in how far this is true is difficult to say);
- less burning of vegetation;
- more crop remainings in the fields which appeared good fertilizers;
- more sugarcane;
- no quarrels anymore between livestock keepers and cultivators.

Of course everybody perceives the effects differently, and some effects are the result of the same process. Basically their is an increase in area of crops, yield per acre, water, grasses, trees, vegetables and honey.

Specially the effect on soil-fertility is still unclear. Many people expected a reduction of soil fertility after destocking, but farmers claim that it has increased. This means that before destocking the trampling of soil had a negative impact on the fields which was not compensated by the manure which the animals left behind. This shows the importance of the slow decomposition of the crop residues in the first months after the harvest (before it is burnt). It increases the organic matter content and reduces the wind erosion. At the same time it shows the importance of the soil structure which is a crucial factor in water infiltration (and thus also in run off and erosion) at the beginning of the rainy season.

Although these are the basic processes it is still unclear what the actual contribution of the different factors is. And how will the lack of manure affect the fertility in the long run (after 10-20 years) when all manure which was in the area before destocking is worked out? These question are of major importance for all semi-arid areas in Africa. The PPS report describes how in semi-arid West Africa a remarkable large part of the N in the natural vegetation is recycled in a situation without cows. Possibly the same counts for crop residues (f.e. in par. 6.5 it was assumed that 45% of the N in crop residues is finally returned to the soil which is nearly the same as when cows are grazing the field, see 7.2.6.4). Despite the fact that no base line study was done before the destocking, Mvumi offers an unique possibility to study these aspects of the relation between livestock and crop production.

Not mentioned by the respondents but noted in the Mvumi hospital is the marked reduction since 1986 of the incidence Trichoma in the Mvumi division. Trichoma is a common eye-disease in Dodoma region which is transmitted by flies. It's reduction means that the hygiene in the area is improved. This may also cause a reduction in other diseases but this is not noted in the Mvumi hospital. Another not mentioned advantage is that the roads suffer much less from erosion. This makes the maintenance of the roads cheaper.

7.4.3.2 Economic value of the benefits

It is very difficult to asses the economic value of the advantages mentioned. Some farmers claimed yield increase of 50%, some even talked about yields twice as big as before 1986. The last figure seems not realistic, but an increase to compensate for most of the loss of income of 6% seems possible as a combined result of the increase of the yields per acre (10%) and the increase of the cultivated area (10%). This gives an extra crop production of 20% or 7% of the income/cap. (see 1.5.1). For the livestock owners the loss of 13% can not be compensated.

The losses on the nutritional side can be compensated: an increase in crop production of 25% means that an extra 40-50 kg of grains and/or legumes are available which contain more protein and energy than the 6 kg of meat and the 25 l. of milk per capita from the livestock before the destocking.

Destocking also means that the system has become more sustainable. In future more people can be fed, more firewood and construction wood is available and more water. This also means a reduction of the workload of women in the future. At the moment this is hardly the case as HADO does not allow people to cut many trees.

Some estimates can be made about the reduction of the workload of the herding itself. Probably about 1,000 people were watching the herds and as many of them where children they never went to school etc.. If 500 were grown ups, they can now work on the fields (or elsewhere). If they now earn 250 Tsh/day for 180 days per year their total income is 21 million Tsh. or 420 Tsh./cap. (= 0.8 US$ or 0.8% of Gross Product per capita).

7.4.4 Preliminary conclusion on destocking

To come to one final conclusion about the (economics) of the destocking is not possible. But some partial conclusions can be drawn:

- the destocking made agriculture in Mvumi more sustainable;
- the destocking had a positive effect on those 85% of the households who had no livestock; in economic terms, In nutritional terms and in terms of workload (f.e. for women in the future);
- destocking had a very negative effect on the households (15%) which owned livestock;
- the loss of saving possibilities is a severe problem for the society at large;
- destocking meant a mass transfer of income from the richer- to the poorer segment of the population;
- also in the case of sweet potato producers it meant a loss while new possibilities appeared for sugarcane producers;
- destocking lead to less Trichoma and possibly to more malaria and malnutrition;
- destocking lead to a remarkable recovery of the natural vegetation (shrubs and grasses) and ruminants are needed to make optimum use of this resource;
- zero-grazing in the destocked area is ecologically and economically viable and has the potential to compensate for a large part of the losses in milk and income if marketing can be assured;
- most people in Mvumi consider the destocking in 1986 as positive, and they consider it impossible to let the animals come back.

A last remark must be that destocking reduces the problems in one area (in this case Mvumi) but increases problems in other areas. So complete destocking of large areas is not wise. Also in the case of Mvumi partly destocking in the western/northern part would have been sufficient. Of course just reducing the number fo animals to f.e. half of the original numbers would have been better, but seeing the problems with leadership in Mvumi it is hard to see who could implement such a policy.

Destocking can also be seen as part of the natural process of livestock disappearing from the farming system. In that way the destocking and the subsequent introduction of zero-grazing gives valuable insight in possible future farming systems. All actors involved should learn as much as possible from this large scale experiment so that other areas can profit from the experience and so that all described losses to many people in Mvumi are not in vain.

In general the destocking did not turn out to be so bad as expected. The major problem is possibly the lack of saving possibilities and the chance of severe hunger in very exceptional cases. In those years the GOT and other organisation should give Mvumi priority when it comes to food distribution.

7.5 Non-ruminants

The number of pigs is increasing quickly in Mvumi. By the time of the destocking there were no pigs, but now there are several hundreds of pigs, forming a major source of meat in the division. Most of them are in Chanhumbe, Idifu and other villages bordering the Mpwapwa district where they got their supply of piglets. During the RRA in 1991 seven people (13%) owned pigs, 4 of them were living in Idifu. One farmer had 16 pigs, the rest had only one or two. Many people said they had plans to keep pig in the (near) future.

The housing is usually poor but still it is a quite an investment for the farmers. Most are kept in small stables made of poles with a roof of soil (like the traditional houses). Sometimes sheets are used. They are fed with millet-, sorghum- and maize bran and by-products of beer preparation etc. The biggest health problem is worms and a lethal disease which was never properly diagnosed (African Swine Fever?). In 1993 it killed over half of the pigs in the eastern part of the division.

Most farmers (65%) had chickens, on average they owned 11 of them. The maximum number found was 30. The chickens are roaming around freely and eat whatever they find. Sometimes they are given maize bran. The main problem are diseases; specially the Newcastle disease is a major death cause. Farmers complain that in the period June-September the majority of the chickens dies. This hinders all investments in poultry. Few eggs are eaten and few chickens slaughtered as everybody tries to have as much chickens as possible after the disease has passed. A few people keep other small animals like ducks and rabbits.

All animals are competing for the same feed: millet-, sorghum-, and maize bran and by-products of beer production. Which of the animals is most suited is hard to tell. The pigs rearing is the most intensive system and therefor might be the most efficient one. Is also has the advantages that it brings in an amount of money, at one time, which can not be generated by the others. On the other hand it requires higher investments.

8 THE TREE COMPONENT OF THE FARMING SYSTEM

8.1 The collection of wood

As HADO does not allow any cutting of trees inside the division, most of the fire- and construction wood is collected outside the division (some is illegally cut in the area). During the RRA most households said they need two (big) bundles of firewood per week.

Those living near the hills surrounding the division need 5 to 7 hours to collect one bundle of firewood. For those in the centre of the division this increases till 8 to 9 hours. Construction wood is even more scarce. On average it takes 7 to 8 hours to collect them and some people even return only the next day. In general the picture is worse in the most densely populated villages in the middle of the division (M. Makulu, M. Mission, Ilolo, Handali, Nghahelezi, Ndebwe).

The scarcity of wood is reflected in the prices. In 1991 in most parts of the division a bundle of firewood was sold for 100 Tsh. In 1994 the price is 200 Tsh in the dry sesason and 250-300 Tsh. in the wet season. A post or pole costs resp. around 300 and 500 Tsh. near the source; in the central parts of the division this can be as high as 500 to 800 Tsh..

Figure 17 Mainly a women's job

The collection of firewood is mainly a women's job, but also children are carrying it (over long distances!) and a few men. In some areas some commercial charcoal production is taking place. Recently this is increasing as the road to Dodoma has been improved. Men usually collect building posts.

In table 14 it can be seen which trees were mentioned most for the use of firewood and construction wood. It shows that the 3 mostly mentioned species are all Acacia's: 'Mkambala' (A. mellifera), 'Mfuku' (A. nilotica) and 'Mzaza' (A. senegal). The first is the favorite tree for construction as it is fairly straight and resistent against termites. It is also used a lot as supporting poles for vines of the grapes. Acacia nilotica is used for both purposes, it makes a good charcoal, as does A. senegal.

Table 14: The use of the most mentioned local tree species

local name	scientific name	number of times mentioned as: constr.wood	firewood	total
Mkambala	Acacia mellifera	30	18	48
Mfuku	Acacia nilotica	17	19	36
Mzasa	Acacia senegal	2	22	24
Mjiha	Dahlbergia sp.	10	8	18
Mtema	?	2	14	16
Mgweru	?	3	9	12
Mkakatika	Cassia abbreviata	5	5	10
Mkungugu	Acacia tortilis	0	8	8

Source: RRA 1991

8.2 The scarcity of tree products

Of course walking 8 hours for a bundle of firewood seems long, but during the RRA in 1991 many respondents said that they did not consider the scarcity of wood a big problem as they were used to walking long distances. Problems like water shortages, diseases, lack of medical care and hunger were mentioned as the biggest problems. When women were asked where their children would collect firewood they answered that they would have to walk further than they do themselves now. But most believed that in the future firewood would be available. Men said the same when asked where they would get constructionwood in the future. Can these impressions be supported or contradicted by some data on the production and consumption of wood?

In general 1-1.5 cubic meter of fuelwood is needed per year. For the total wood consumption often 2 cubic meters is mentioned. However Skutch (1987, quoting Skutch 1983) measured in Dodoma a consumption of 0.9 cu. m./year/-capita when firewood is scarce. An additional 0.2 was used for beer brewing. Hadjivayanis and Nordbo (1987) mention a harvest of 0.8 cu.m/year including felling for marketed charcoal production. In Shinyanga Gullison found even a lower consumption of 0.3 cu. m./year/capita when people lived far from the source of firewood (Skutch, 1987). As in Mvumi firewood is scarce it is estimated that about 1 cu m/year/capita is used. Two bundles/week per household is equal to about 0.8 cu.m. per year/cap. if the households have 6 members, the bundles are 30 kg each and the density of the wood is 600 kg/ cu.m.

A consumption of 1 cu.m./cap. means that people have already adjusted themselves to the situation. Often two meals are prepared per day, and in the rainy season, when both food and firewood are scarce, many times only one. Another example is the construction of houses. Traditionally a 'tembe' had walls of woven twigs which could be taken along when a house was moved over a short distance. These days walls are made of mud only. In the western part of the division even the post supporting the roof outside the walls are no longer used. The roof is supported by the walls and some posts inside. In others parts of Tanzania where also 'tembe's' are built the situation is even worse. In some houses in Shinyanga even the long poles in the roof (the 'miamba') are no longer of durable wood, f.e. sisal poles are used.

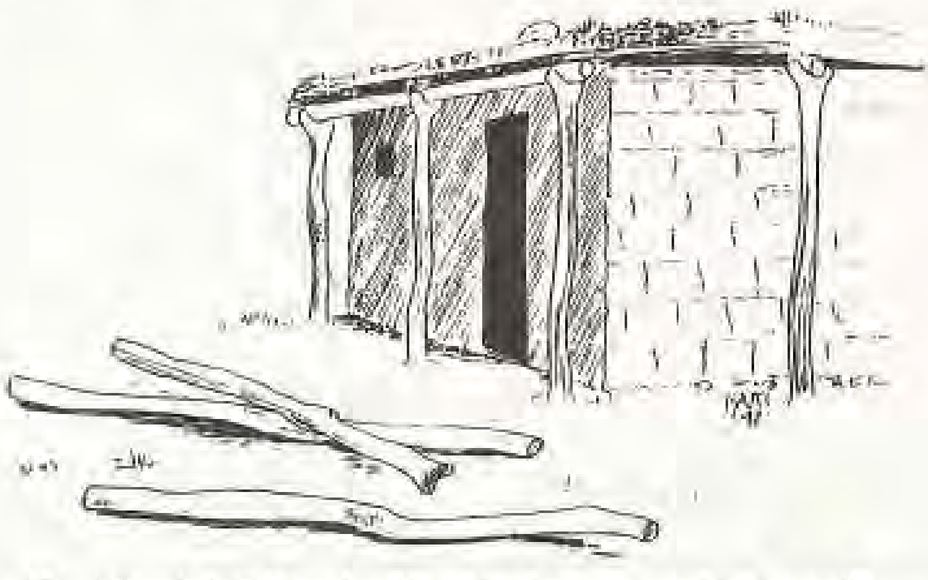

Figure 18 A 'tembe' with mud walls and a few post outside the walls

To estimate the productivity of the natural vegetation in Mvumi it is assumed that about 30% of the area is cultivated, about 50% is covered by unproductive thicket and 20% is covered by reasonable woodland. Allen's study (1986) showed that the natural vegetation in East Chenene Forest Reserve (North of Dodoma town; ca. 600 mm rainfall) mature dry woodland produced between 1 and 2 cu m per ha or 1.5 on average. A tentative guess for the thickets in Mvumi might be 0.5 cu m per ha (based on Skutch, 1987). Firewood available from trees in the fields can be assumed to be 0.25 cu m/ha (estimate on the basis of figures in Leach and Means, 1988). This gives a total (fire)wood production of roughly 46.000 cu.m. per year, or about 0.9 cu m/capita. Seeing the consumption figures mentioned above there is a moderate shortage of firewood in Mvumi.

It is clear that these figures are manipulative but at least they show that the shortage of firewood is not as dramatic as might be expected in an area which was destocked because of severe erosion problems. On the other hand firewood will be more scarce in the future as the population still grows.

8.3 The planting of trees

Of the households visited during the RRA 70% had planted trees, mostly they planted up to 10 trees around their homestead. Other (mainly elder) people said they had never planted a tree and that they only rely on God who has provided trees to them all the time and who will do this again.

When people try to plant trees the difficulties are many. First of all seedlings are not available or they are brought too late and without notice by HADO. Secondly many people plant the seedlings in too small planting holes, which are only made after the rains have started, so not much rainwater infiltrated. Thirdly when they are finally planted the rains can stop any time and either the seedlings die or they have to be irrigated regularly. Fourthly the rainy season is so short that many seedlings which survived till the end of the rains still die after some months in the dry season.

Table 15 shows which trees were planted. The most planted species are Leuceana, Cassia, Neem tree, Eucalyptus and Melia. Although Leuceana is considered by experts to be a firewood species many people do not agree on this. They find the wood too soft, too thin etc.. Also they associate it with a similar looking local tree ("msele", a Delonix sp.) which produces very bad firewood (smoke). So nearly nobody knows the use of it and they only plant it because HADO brings many Leuceana seedlings and they survive well. The most mentioned reason for planting trees is shade, followed by constructionwood. Planting for firewood and medicine (Neem tree) are less important reasons.

Table 15: Trees planted at the homestead

species	number of h.h. planted	number planted: average	number planted: maximum
Leuceana leucocephala	13	3-5	18
Cassia siamea	8	1-2	4
Melia azedarach	7	3-4	14
Azadirachta indica	7	2-3	6
Eucalyptus sp.	7	1-2	2
Mdawi (Chordia sp.)	4	2-3	4
Mkumba	3	2	3

Source: RRA 1991

When farmers are asked which species they would like to plant, they think immediately of exotic species as they are the only ones which are brought.

Quite some farmers did not know the name of any of these. Those who expressed their preference usually named fruit-trees (guava, papaya, citrus and mango) and Neem tree (Azadirachta indica), Cassia siamea and Melia azedarach. Those who knew Eucalyptus sp. mentioned this also.

As can be seen in table 15 next to the exotic species also some local species were planted by the farmers: 'Mdawi' (Chordia gharaf) and 'Mkumba' specially. These species are not mentioned by Westman (date unknown) as promising local species for tree planting. He does mention 16 species which could be tried, among them are two important firewood and constructionwood species: 'Mkambala' (A. mellifera) and 'Mzasa' (A. senegal). Of the 16 species Westman mentioned 2 were found to be planted by farmers: 'Mgombogombo' (Combretum spicatum) and 'Mzasa' (A. Senegal).

As Allen (1986) found that the productivity of exotic species (Cassia siamea and Eucalyptus citriodora) was not significantly higher than of local species one could argue that local species should be encouraged. The MRTC tried this (as other projects in Dodoma have done and are doing) but it is quite difficult. First of all their propagation is often more difficult or at least unknown. Secondly it proofed more difficult to motivate people to plant and maintain a local species ("that one germinates itself here so why should I bother to dig a big hole for it and water it ...."). Thirdly it might be that local species perform as well as exotics when grown in a woodlot but when grown as individual trees (like in most cases in Mvumi) exotic species might perform better.

9 CONSTRAINTS IN THE FARMING SYSTEM

From the previous chapter several constraints in the farming became appearant. Some are more technical, others more of a socio-economic nature. They are summarized here below:

1. High population pressure
Seeing the natural resources (climate and soils) too many people are living in Mvumi. This results in out migration of the strongest people (young men), leaving behind the vulnerable ones (women and children).

2. Water
Both the quality and the quantity of water is insufficient in most of the villages. While water is necessary for many activities many households only use one bucket of water per day.

3. Poverty
The farmers of Mvumi are poor and their immediate needs are so big that they can hardly invest in their future. Even farmers who get a good yield do not have cash money to buy the necessary inputs for the next season. Also the resulting risk avoiding behavior leads to a lower productivity in agriculture than necessary.

4. Poor leadership
The ujamaa policy of the Tanzanian government was forcefully implemented in Mvumi. Many villages therefore are no social unit. The elected leaders are usually weak and poor people try to avoid any contact with the government or outsiders.

5. Weak position of women
Traditionally Wagogo women were not very prominent in social live. Their weak position leads to an uneven distribution of tasks between men and women, resulting in a too heavy workload of women in both the productive and reproductive sphere. This is engraved by the large out-migration of men. Next to causing much suffering among women and children these processes also reduces the productivity of the farming suystem.

6. Climate
The short and erroneous rainfall does limit the agricultural production very much. As it forces the farmers to practise dry planting the possibilites to improve the production are limited.

7. Poor soils
The soils in Mvumi are poor or very poor. Specially N is lacking and to a lesser extend P and organic matter. In the eastern part of the division also the soil structure is a problem.

8. Poor farming techniques
The climate does not allow much crop diversification and the high population pressure does not leave much room for fallow periods. This results in a permanent cropping of a few crops leading to a on going depletion of important minerals. Specially N will be a more an more limiting factor as farmers are burning the crop residues. As farm yard manure is not available other ways of improving/sustaining the soil-fertility have to be sought.

9. Shortage of milk, meat and manure
The destocking reduced the availability of milk, meat and manure in the area. Although from calculations is becomes clear that also before the destocking not everybody enjoyed the availability of these items still it is a major problem.

10. Shortage of (fire) wood
Due to the high population pressure and the low productivity of the natural vegetation there is a shortage of (fire)wood in the area. As HADO prohibited the cutting of wood in the division everybody has to collect it from outside. So the hills surrounding the division are over-exploited and in the future people have to walk even further. The destocking in Mvumi might be a useful instrument to reduce the shortage of firewood in the long run, but for the time being it is not.

10 POSSIBLE INNOVATIONS

10.1 Introduction

Following the problem analysis many possible innovations can be identified to improve the productivity and sustainability of the farming system. And many will be discussed here, in more or less detail, with the aim of selecting the most promising ones. The selection is based on two sets of criteria. The first are 3 pre-conditions which must be fulfilled. The innovation must:

- increase the ecological sustainability of the system;
- be economically viable (on the short to medium term);
- have no negative effect on the position of women.

The second set are desirable criteria. They are taken into account as much as possible, but failure on one of the factors does not automatically mean that the innovation should not be introduced, it can also mean that a project/-program which tries to introduce the innovation should take action on the factor involved. The following criteria are used:

- risk;
- simplicity;
- integration/side effects;
- labour requirement;
- capital requirement;
- acceptibility to farmers (a.o. social/cultural factors);
- institutional sustainability;
- marketing.

All innovations will be discussed first and in the end a decision matrix of all innovations and criteria is made in order to come to a final assessment of the innovations: which one can be readily tried, which ones seem less appropriate and for which ones more research is needed.

There is a difference in the depth into which the innovations are discussed, because some innovations are already tried out for a few years and are well studied while others are just ideas which have not been tried out yet.

Before discussing the innovations one point needs to be stressed. Most innovation need to be supported by an extension service, which on its turn needs the participation of the population to be succesful. To get the farmers in the villages participating, more trust among each other is necessary and a more prominent role for women in decision making. Although the question of how this can be achieved is of utmost importance (seeing the history of leadership described before) it will not be dealt with here.

10.2 Improving the cropping system

10.2.1 Introduction

Crop production is the most important component of the farming system so it should get first priority. Within MRTC and outside MRTC many ways to try to improve the crop production are discussed on a nearly daily basis between farmers, extension workers and projects. However no clearcut solution has come forward, thus indicating the difficult environment of Mvumi. The many options are listed below:

- improve crop husbandry
- use new varieties or new crops:
  - new sorghum and millet varieties
  - sunflower and its oilpress
  - diversification
- improve the fertility of the field:
  - use chemical fertilizers
  - incorporating crop residues
  - greenmanuring
  - composting
- mechanisation
- soil- and water conservation
- intensive gardening.

Although in practice some of these innovations have to be introduced together as a package, here they are discussed seperately to examine which part of an extension package is most attractive and which part least.

10.2.2 Improve crop husbandry

The innovation
Crop production can be optimised by simply working harder with the existing technology. This means: deeper digging and better weeding. As such this can hardly be called an innovation, it is an existing ongoing intensification which is driven by the narrowing ratio between land and people. So the digging has improved over the years and still is. Even farmers in the eastern part of the division admire the way the people in the western part are doing the digging "they really dig deep, we are only scratching the soil". The same goes for weeding, in the western part most fields are clean weeded all the time, in the eastern part this is not yet the case.

Possibly it is this intensification which is stimulated most by the destocking. As a result of the deep digging and the good weeding the soils become softer, and as no animals trample it in the dry season they stay soft till the next season. Also the slowly decomposing crop residues increase the organic matter content and the softness of the soils. As such this again makes deeper digging easier. There are signs that a next step might be the cultivation of fields before the rains. This would increase the production as well as reduce the erosion from the first heavy rains.

Although these processes are more or less autonomous it is crucial that the extension service keeps on emphasising it. Actually it can even encourage these trends by messages which make this intensification more profitable. These can be higher planting densities, planting on rows and/or new varieties which respond better to improved management. New varieties are discussed elsewhere, here the other aspects are treated: deeper digger, better weeding, higher planting densities and planting on rows.

The potential of this intensification should not be under-estimated. For example the preliminary results of the on-farm trial with millet show that the average yield of the local variety was over 1,000 kg/ha, or twice as much as the average yields on 'normal' fields. As no external inputs were used and the fields were not better than average this extra yield is just a result of better crop husbandry.

Pre-conditions
As the choice is between clearing more fields or using the existing ones more intensive then ecologically the last one is to be prefered although a higher yield per acre means that the soil is exhausted quicker if no (in)organic manure is used. On the other hand this can only be used when the crop husbandry is optimal. If one considers the N-loss per kg of grain produced (which is a better criterium as also the grains imported in Mvumi lead to nutrient losses elsewhere) the improved husbandry makes crop production more sustainable.

The economics of this intensification are not known. It depends much on the opportunity costs of labour which again depends on prices of crops, on the land/human ratio and on off-farm opportunities in- and outside Mvumi. From the fact that farmers are intensifying themselves one can conclude that it makes economic sense. On the other hand it could indicate that people are forced to work for smaller returns per hour. As such planting in lines has possible the highest returns as it is done in the dry season when the opportunity costs for labour are still low.

Special attention is needed for the idea of the extension service (specially Global 2000) to do the digging after the first rains. This has two problems. First of all dry planting nearly always yields better. Only if the digging is done in the first few days after the first rains a better yield can be obtained. So only well to do farmers, employing many people immediately after the first rains, can make use of this technology. Secondly farmers are digging their 'vigundu' field immediately after the first rains. So if they are told to dig their millet field first their question is "and what about my groundnut field?"

As the planting, the digging and the weeding in practice is done by both men and women no specific effect on the position of women is expected. On the other hand women do most of the agricultural work and they will continue to do even more, so in practice they have to shoulder the major share of this labour intensification.

Other criteria
Using more labour per acre usually reduces the risks on crop failure. Only increasing the plant density increases the risk on water shortage at the end of the season.

The techniques discussed here are very simple and acceptable to all farmers. As mentioned it is an already ongoing process, whereby also messages as planting on lines and increasing planting densities are taken up nowadays. Other positive points are that no specific institutions are needed, nor extra capital. The obvious problem remaining is the high labour requirement, but this can also be seen as an advantage because more intensive cultivation is a way to make the available labour productive.

Conclusion
Although the economics of the intensification are unclear it is an on going process enforced by the on going population growth. The extension service should keep in touch with it and encourage it. Its own contribution could be planting in rows, which is in practice linked to higher planting densities and new short straw varieties.

10.2.3 New varieties and crops

10.2.3.1 New varieties of sorghum and millet

The innovation
As mentioned above the intensification of crop production might call for new varieties who respond better to improved management. At the same time these new varities might induce better management. In first instance the choice must be for sorghum and millet as the yield of maize is too risky for normal farmers. Only for some innovative farmers some new maize varieties can be of interest.

Until now Tegemeo sorghum was the most promising new variety. It is a quick maturing short straw variety. It can be planted at high densities (f.e. 75 x 30 cm). It has a high yield potential and as such it is liked by the farmers. However is has some disadvantages. As many improved varieties it suffers more from pests and diseases, both in the field (stalks borers, army worms, head smut and Striga sp.) and during storage. People do not like the taste of it. The pounding takes about twice as much time as traditional varieties and it produces more bran ('pumbe'). Some people claim that it can not be used for beer making, but others say it makes a good local brew if well prepared (meaning that the seeds are only left to germinate 2 days in stead of the normal 3). All this makes the marketing of Tegemeo very difficult, its price is usually (20%) lower than for others cereals. The idea of Global 2000 that companies interested in Tegemeo would come to Mvumi to buy large quantities (f.e. Beer brewers) failed.

In the 1993/94 season the MRTC started on-farm trials with two new sorghum varieties which are not yet released. The trial failed because the seeds germinated very poorly. This was caused by poor storing before they came to Mvumi. On two fields the stand was good enough to give an idea of the yield potential of the new varities. They both yielded about 35% more than the local varitety, Mhoputa, but the difference was not statistically significant. Tegemeo was also included in the trial and yielded even 57% more than the local variety and this difference was statistically significant. So Tegemeo yielded 15% more than the new varieites but this was also not statistically significant. Still the farmers are very interested in the seeds, specially in the SDS type as is has very big heads and is very white. This last characteristic is associated with hardness (so good storing quality) and good taste. The other variety (SV-1) is also liked by farmers because of its earliness.

For the millet the only officially introduced variety is Serere, a very quick maturing short straw variety with small heads. Farmers do not like the small heads. Probably they underestimate the yield of it as it has a higher threshing ratio than traditional varieties. Its very early yield however attracts thieves and birds; as a result the actual harvest can be nil. Partial solutions could be to break off all heads when they flower and harvest only from the tillers, or to plant it later, or to plant it in between the traditional variety, or to scare the birds specially by planting around the homestead. All options are sometimes used.

The MRTC is at the moment doing on-farm trials with two new varities from Ilonga research station. Specially the TSPM 91018 is very much liked by farmers. Preliminary results of the on-farm trial reveal that it yields about 35% more than the local variety and this difference is statistically significant. Other attractive aspects of the TSPM 91018 are that it is fairly early and has a vigorous growth and tall heads.

Figure 19 A participant of the MRTC-Ilonga on-farm trial with millet varieties. On the left the new var. TSPM 91018, on the right the local variety.

In general new millet varieties should get priority as they have a better chance to succeed than sorghum varieties. Their taste is usually more similar to local varieties and as a local food crop it has no marketing problem. Also the problems with pests and diseases (in the field and during storage) are usually less. New sorghum varieties can only be encouraged when a clear market has been found. At the moment this is not yet the case, despite some interesting stories on new technical possibilities of using sorghum in beer brewing.

Pre-conditions
New varieties lead to higher yields per acre, specially in combination with a more intensive crop husbandry. Short straw varieties also lead to a more efficient use of N, the limiting factor in crop production. In traditional varieties the harvest index is too low, often only a quarter to one third of the total dry matter production is grains, the remaining are stalks which are burnt (and N disappears in the sky). Short straw var. have a better harvest index, up to half of the dry matter is grains, so per kg of grain harvested less N is spoiled (see 10.2.4.2).

As the only investment are seeds new varieties are economically attractive if people eat them themselves or if marketing is assured. For sorghum farmers can, if they are carefully, select their own seeds from their fields. For millet this is not possible as it is for 95% outpollinating, so some isolated fields are needed to generate new seeds every year. Under the new seed policy of the GOT it is possible that farmers or projects like the MRTC are doing this commercially on a small scale (Lujuo, 1994).

The use of new varieties will not have any specific effect on the position of women as long as they are involved in the selection of the new varieties (testing the post-harvest aspects).

Other criteria
The new short term varieties need less rain than the traditional varieties which makes them less risky. This is very much appreciated by farmers. On the other hand the risks of pest and diseases is bigger. In general it is a very simple and acceptable innovation with little side effects.

As mentioned marketing is a problem at least for sorghum varieties, so for the on farm trials marketing must be an explicit selection criteria. As long as there is no sorghum variety which has a good stage quality and a good market, priority should be given to new millet varieties.

Conclusions
As this innovation has hardly any negative aspects and several positive ones it should be implemented. Of course as much as possible in close cooperation with farmers and the Ilonga research station, responsible for breeding new sorghum and millet varieties.

In general it seems that new millet varieties have a better chance of success as the taste and the storage is usually no problem. As a result also the marketing is no problem.

10.2.3.2 Sunflower

The innovation
In Mvumi sunflower seems a good extra crop in the system. Actually it is already grown on a small scale, but there seems scope for an increase in area and productivity, specially when a new variety, called "Record" is used. This varietie is quick maturing, gives higher yields and has softer seeds with an higher oil content.

A major advantage is that it can be planted after the other crops. So if people delay in cultivating a certain plot or when the planted crops have died they can still plant sunflower until the end of January. It can also be easily grown together with other crops, specially groundnuts. These are planted after the first rains and the sunflower is planted in between later. This is called 'relay-cropping'.

Another attractive aspect is that a cheap hand operated sunflower oil press is available (Bielenberg ram press). This makes it possible to produce cooking oil locally, reducing cash expenditure (at local and national level) on cooking oil from outside Tanzania.

Pre-conditions
No effect on the ecological sustainability is expected.

Its economics appear to be good. Although at the MRTC 6 bags/acre were obtained without external inputs, one acre of sunflower is estimated to produce 3 bags. One bag can produce about 15 liter of oil. The cultivation/harvesting/treshing and winnowing of one acre is estimated to take about 300 hours (a high estimate, similar to grains although less weeding is needed, specially when it is relay-cropped). The extraction of 45 litres of oil costs about 30 hours and 2,250 Tsh. (50 Tsh. per litre for the press). So the total costs for 45 litres are 2,250 Tsh. and 330 hours. A litre of oil in whole sale costs about 450 Tsh. in Mvumi Mission, but if bought in small amounts it may costs up to 700 Tsh. in the villages. Even if the price is taken to be 400 Tsh. the return is 48 Tsh. per hour, well above the return for other crops.

As the oilpress costs 45,000 Tsh. it needs to press only 900 litres of oil for 50 Tsh. to recover its costs. This is equal to 60 bags of sunflower or 20 acres in pure stand. If 25% of all groundnuts in Mvumi would be relay-cropped with sunflower with a yield of half a bag per acre, in total 1,750 bags would be harvested. As per day 1 bag can be processed (20 per month) 15 presses could be operated for 6 months. Each press would produce 1,750 litres of oil and generate 87,500 Tsh. of income, enough to make it economically attractive. The total oil production would be 0.5 litre per capita per year. This would save about half a dollar per capita on expenditure, or 1% of the available cash per capita.

The investments for the press are relatively little compared to the investments in labour. This makes it likely that even in the future, when labour is relatively getting cheaper and imported cooking oil more expensive, the innovation will be economically viable.

As the women are the ones who buy the cooking oil, they would benefit most from being able to produce it locally. Of course it increases their workload but as they earn more per hour this is not a problem. From the MRTC experience with sunflower it seems that women are more interested than men, partly because the MRTC is planning to introduce the oilpresses via women groups.

Other criteria
No particular risk is envisaged: the crop as such can be very well intercropped and is fairly drought resistent. The innovation is also simple and straightforward. Although no exact figures are available sunflower seems to need less labour then most other crops as its big leaves reduce weed growth effectively. The pressing can be done in the dry season, when opportunity costs for labour are low.

The investment for a press exceeds the capacity of most people so it needs a loan (to be offered to womengroups in first instance). The seeds are not expensive as only small quantities are needed: one kg is enough for half an acre. However the seeds need to be brought by an institution for quite some time. Once the innovation is accepted good relations need to be established between the owners of the presses and the manufacturer in Dodoma.

Sunflower as such is known and the first reaction of (female) farmers on demonstrations of the press by the MRTC in 1992 were positive. Unfortunately the first year all sunflower planted in the two pilot villages, Idifu and Igandu died because of drought (as did all other crops). In the second year women from Igandu and Chanhumbe planted sunflower and got a reasonable yield. They borrowed the press of the MRTC. This made them enthusiastic and in 1994 in both villages over one bag of seeds was planted.

The press cake ('mashudu') is a very high quality feed for both cows and pigs, which are both kept in increasing numbers all over the division.

For the time being no marketing seems necessary as people will produce first for their own household. Later they could start to exchange or sell to others in the villages. If the introduction becomes very succesfull markets in Dodoma could be sought. The only problem which will arise is that the oil needs to be refined more. This can be done by siefing or boiling with a bit of water. In the last case a lot of firewood is needed.

Conclusion
The economics of sunflower oil production seem very attractive. Hardly any negative aspects can be mentioned. It only needs quite some institutional support, but that can be provided by the MRTC in cooperation with the Village Oilpress Project from Arusha.

10.2.3.3 Diversification

Introduction
A more divers cropping system has several advantages. The posibilities for rotations will be slightly bigger, the diet will be more divers and better, pests and diseases are less easily spread and the farmers are not so

dependent on one crop. On the other hand the marketing of small amounts of several crops is difficult.

Three crops/varieties seem to be candidates for expansion:
- cassave as it is supposed to be able to give a higher yield per acre in terms of energy available for human consumption;
- pigeon pea as it is N-fixing and reducing erosion, perennial and very nutritive for both humans and cows;
- erect varieties of cowpea.

In practice cassave is grown more and more in Mvumi, specially after the destocking as livestock does not destroy the fields anymore. It is quite often used by bigger farmers to pay their labourers with.

Pigeon pea does not seem to increase. When farmers are asked why they do not grow more, they say that it does not do well on all soil types, that it is attacked by quite some pests and that there is no market for it. In the past when the Indian shop keepers were still in the villages they used to grow it more. The Wagogo say they like to eat pigeon pea (and other legumes) but the amount they actually consume is quite small. Sometimes it is mentioned as a possible crop for alley-cropping but the problem is that it can not withstand frequent pruning.

Cowpea is a traditional crop in Mvumi but erect types are not seen, also as the major aim are often the leaves and not the seeds. Many people showed some interest in erect types as they are quick maturing (drought escaping) and may be better fit for row intercropping. In Hombolo research station many of these varieties are tested but they all suffer a lot from pests, both on the field and during storage. No introduction of these varieties has taken place in Mvumi.

Conclusion
For all crops it is difficult to come up with a clear conclusion as they are already known by the farmers. For cassave the first thing to do is screening the existing varieties to see wich are the best and whether new varieties are needed. For pigeon pea the same can be done, but marketing might be the biggest problem. For cowpea some new varieties could be distributed to farmers for on farm testing/screening. In all cases more in depth research to the existing situation is needed.

10.2.4 Improving the nutrient balance of the fields

10.2.4.1 Introduction

The maintenance of soil fertility is the heart of any farming system. In par. 6.5 the traditional methods for this are explained. As the major conclusion was that these methods did not replenish the nutrients taken up by the crops new and other methods have to be sought. Basically three methods are available: chemical fertilizers, organic fertilizers (greenmanure, crop residues and compost) and agroforestry. As the last one has more aims than just restoring soil fertility it is dealt with later.

10.2.4.2 Use of chemical fertilizers

Introduction

As shown in par. 4.2.3 most soils in Mvumi are N-deficient. Small amounts (25 kg N/ha) of chemical N-fertilizer can solve this problem. It is often stated that in the long run fertilizers alone are not able to sustain yields as trials have shown that the permanent use of fertilizers exhausts the soil. But more can be said: in those trials usually much more fertilizers are used than proposed here. Usually a composite fertilizer is used in quantities at least double the amount recommended here. Also mostly the soils were not as N-deficit as the ones in Mvumi seem to be. Another important factor is that many N-fertilizers make the soil more acid. The soils in Mvumi will not suffer much from this easily as they have a high pH. Also the type of N-fertilizer matters: Ammonium sulphate is the worst, the next bad one is urea and the best is CAN (Calcium Ammonium Nitrate, which is actually not acifying the soil) which should be used in Mvumi. In a trial at the MRTC, applying CAN for 3 years did not lower the pH-KCl more than 3 years cropping without fertilizer.

A major bottleneck for the use of any fertilizer is the risk that it will only lead to an extra vegetative growth while at the time of flowering and seed filling the water resources are exhausted. Another problem is that if a farmer fails to manage her field well the expensive fertilizer is lost. To prevent this the N should only be used as a top-dressing on well established fields and when the prospects for rain look good.

Pre-conditions

Using small amounts of CAN will have no negative effect on the sustainability of the farming system. It actually might stimulate soil life and induce the farmer to pay more attention to his fields which could reduce the area of new land opened.

Table 16 on the next page shows in how far 25 kg of N can improve the N-balance of a field. The table is based on the following assumptions (see 6.5 and 7.4.2.2): the N-content of the cereal is 1.5% (so 9% protein) and of the straw it is 0.6% (so a CP of 3.5%). The Harvest Index for traditional varieties is 0.25 while for the short straw varieties it is 0.5. The erosion losses are taken to be 5 kg of N/ha in all situations. The total N from the atmosphere (incl. fixation) is taken to be 5.2 kg/ha and the N returned from crop residues is assumed to be 45% of the total N in the crop residues.

Table 16 N-balance for traditional fields, for improved husbandry with short straw varieties and with new varieties and N-fertilizer

	traditional	new var.	25 kg N/ha
grain yield	500	1,000	1,500
straw yield	1,000	1,000	1,500
N uptake	- 16	- 21	- 32
N lost via erosion	- 5	- 5	- 5
N added from atmosphere	5	5	5
N from crop residues	4	3	4
ferlilizer N	—	—	25
N-balance	- 12	- 18	- 3
N-balance per ton of grain	- 24	- 18	- 2

It appears that the traditional system is not efficient in term of N utilisation. Using FYM only slightly improves the situation (2.2 kg/ha, see 6.5). Using short straw varieties under improved husbandry also improves the N-balance slightly and 25 kg of N of N can make the balance nearly neutral. In Jan. 1994 this theoretical model was checked via soil samples taken after 3 years of cropping with and without N fertilizer. It appeared that the N-status of the fertilized crop was slightly lower than the control plot! This can be explained by the N of the fertilizer which is easily leached to below 15 cm (the depth of sampling) or even below the rooting zone. If half of the N applied is leached, the N balance of the field is - 15 kg/ha, similar to the others. In this case the N loss per ton of grain is about half of the others. In general the data show that intensifying crop production improves the N-balance as it reduces the cropped area and thus the area prune to erosion.

What extra yield is needed to make the use of fertilizer economically viable? In 1994 the price of N from CAN has risen to 370 Tsh. per kg in Dodoma. Transport costs (200 Tsh/bag) and the application costs (1,000 Tsh/bag/acre) add another 92 Tsh./kg. So the total costs are 462 Tsh. per kg of N applied. How many kg of grain is this? It is not simply 462 divided by the average market price as the extra grains mentioned here still have to be harvested, treshed and winnowed before they can be marketed. Also an extra return is needed as an interest to the capital involved, otherwise the farmer better buys food from others after the harvest. If harvesting, treshing and winnowing are equal to 15% of the grain price and if the returns to the capital is 10% (in 5 months) and if the price of grains is 35 Tsh. immediately after the harvest, then 17 kg of extra grains are needed to make the use of fertilizer

Other criteria
As mentioned the innovation is risky. If the rains fail (which can happen any time in Mvumi) the total investment gets lost. In terms of local income the amount of capital needed is big. Apllying fertilizer is not too difficult, but it needs some follow up by the VEW's. This and the input supply needs an institution to take care of it. Culturally using fertilizers is acceptable as shown by the experiences of Global 2000 and MRTC.

10.2.4.3 Organic manures

10.2.4.3.1 Introduction

The last decade a lot of attention is attracted to the so called Low External Input Sustainable Agriculture (LEISA). Organic manures are an important aspect of LEISA as they are locally produced. Compared to chemical fertilizers they have several advantages: they improve the soil structure (leading to a better water infiltration, better aeration, improved root formation and less erosion), they improve the fertility with both macro and micro nutrients and they improve soil life (leading to less diseases).

Still many questions remain: what is the optimum use of any amount of organic matter? What are the economics of it and what are the major determinants in the economic picture? Three options ranging from simple to complex are reviewed here. The most simple option is: incorporate the crop residues in the soil. More complex is the option to grow organic matter for the purpose of incorporating it (greenmanuring). The most complex is to take the crop residues from the field, mix them with higher quality organic materials in a compost pit and return them to the field afterwards.

10.2.4.3.2 Burying crop residues

Introduction
Simply burying the crop residues would be the most efficient way of preserving the nutrients from the crop residues. The problem is, when this has to be done. At the end of the dry season the soil is too hard even for a normal land preparation so it will be impossible to incorporate large quantities of organic material in the soil at that time. The much quoted advice of researchers to do the incorporation at the end of the rainy season is also not feasible. The rains stop in April while the harvest is done in May- July, so only in July people could start the work, but the soil is already dried out by that time. The last possibility is a tractor to plough the crop remainings under. Apart from the poor economics of ploughing with a tractor (see 10.5) many times the soils in Mvumi are so hard that also a tractor fails to plough them in the dry season. A partial solution might be to bury only part of the organic material in contourbunds or concentrate it on a small area where it is as much as possible incorporated.

Another problem is the low quality of the stalks (= a high C/N ratio of 70) which leads to an initial N-fixation which might lead to a lower yield in the first year. A third drawback is the chance of more pests, although generally the advantages of burying are found to be bigger than the disadvantages of more pests.

Pre-conditions
This innovation obviously improves the sustainability for the farming system. No data on its economics are available but it is clear to all farmers with whom this idea was discussed that the labour requirements are excessive. A model calculation can check this. If the crop residues of one acre are 600 kg with a N content of 0.6% than it would contain 3.6 kg N. In the first year this would not lead to any higher yield but over the years it might give an extra yield of 44 kg of grains (see 6.4) with a value of nearly 2,000 Tsh. As the costs of a normal land preparation are between 2,000 and 3,000 in Mvumi (depending on the village) nobody would do the extra work of incorporating 600 kg of crop residues for 2,000 Tsh., particularly if he is only slowly paid back over a couple of years.

As burying the stalks would be a men's task it would have a positive effect on the position of women who would benefit from the extra yield.

Other criteria
This innovation has been practiced by the VEW of Nghahelezi already for several years, but nobody follows the example. Farmers of the evaluation team (1992) protested against burying stalks as it is too laborious and it would bring pests (stem borers and termites).

Conclusion
With the present available technology (hand hoes) it is not economically attractive to incorporate large amounts of low quality organic matter in the hard dry soils of Mvumi.

10.2.4.3.3 Greenmanuring

The innovation
Greenmanuring is the growing of a crop with the single purpose of ploughing it under before it matures. In Mvumi this would mean that on the field involved no normal crop could be grown. Seeing the shortage of land this is not a realistic option. A related option is to sow quick growing, N-fixing, drought resistant crops/shrubs in between the fieldcrops halfway their growing season. The crops/schrubs would use the remaining water of the season and by using their deeper roots even carry on in the dry season. The organic matter they produce can be incorpated in the soil before the next season. An additional advantage is that they will suppress weeds. Some have usefull "by-products" like food (cowpea/pigeon pea) or fodder (Crotelaria sp.). Most suitable species for Mvumi seems to be: pigeon pea and Sesbania sp.

Pre-conditions
It is clear that greenmanuring is ecological sustainable. It reduces erosion, it increases the org. matter of the soil. However in general due to the often occuring drought stress dry matter production will be low. As under water stress the N-fixation is even more reduced than the overall biomass production, the amount of N gained will be low.

In 1885-87 a trial was conducted with Marejea (Crotelaria sp.) as a greenmanure in Hombolo. Table 18 on the next page shows the results. The conclusion is that it can not work. It competes too much with the crops and the organic matter it produces is too hardy and bulky to be worked under with a handhoe (Chilangane, 1990). The data on groundnut indicate that foodcrops like groundnuts, cowpea and pigeon pea are more suitable. In this case it would be more appropriate to talk of intercropping.

Table 18: The effect of intercropping Crotelaria with sorghum and millet

treatment	yields 1985/86 (kg/ha)	yields 1986/87 (kg/ha)	average yield (kg/ha)	yield as % of control
pure sorghum/millet	653	1,260	956	100
Crotelaria at dry planting	85	0	42	4
Crotelaria at cultivation	86	243	164	17
Crotelaria at weeding	484	475	480	50
Groundnuts at cultivation	390	794	592	62

Source: Chilangane, 1990

No effect on the position of women is expected. The incorporation of the organic material will be a man's job. If the scrubs suppress weeds effectively than perhaps the last weeding round can be skipped, thus reducing the workload of women slightly.

Other criteria
Of course it is very risky: the drier the season the worse the competition. It is a simple innovation which does not need any capital nor institutional support (when it is once adopted). The labour requirements for the digging under of the biomass are prohibitive.

Often the integration aspects of this innovation are mentioned (f.e. Crotelaria) can be used as a fodder. This might be true but giving the fodder to cows would reduce the amount of biomass available for incorporation, which reduces the primary effect aimed at.

Conclusion
This innovation is not applicable in Mvumi. Land shortage does not allow land to be left fallow and intercropping the greenmanure leads to severe losses because of the competition for water.

10.2.4.3.4 Composting

The innovation
Another way of making use of the large quantities of low quality organic matter is composting.This is a natural process in which bulky low quality organic matter is transformed in compost, which is less bulky and has a higher quality. As such it could solve the above mentioned problem of the incorporation of large quantities of low quality organic matter.

For composting all kind of organic material is collected, cut in small enough pieces and put together. The C/N ratio of this material should be between 25 and 35. This is a problem as crop residues have a C/N ratio of about 70. So they need to be complemented by high value organic materials, like animal manure, f.e. in a ratio of 50/50. In order for the process to proceed well the moisture content must be around 50% (so water must be added) and a pile needs to be aerated every now and then. In order to prevent the compost from drying it needs to be made in pits.

During the composting process the temperature raises so much that most germs of pests and diseases are killed. The end product is a much finer type of organic material (compost) with a higher N content.

Pre-conditions
This innovation would make the farming system more sustainable. Most of the large quantities of N which gets lost every year by burning the crop residues would be saved.

As no data on its economics from Mvumi are available a model calculation is made to get at least an impression of the possibilities. One ton of compost contains about 5 kg of N (0.5% on fresh weight; Dalzell, 1987). This 5 kg can ultimately lead to a maximum extra yield of 100 kg (so 20 kg of grains per kg of N instead of the 12 kg per kg of N in FYM (par. 6.5)). This extra yield has a value of 4,000 Tsh. In order to make one ton of compost 2 tonnes basic material are needed. According to the Dalzell et al. (1987) the production and application of compost only takes 3 mandays/ton and up to 2,500 litres of water. As the price of water in the dry season is 2 Th. per litre or more, the whole excercise is uneconomic. The more so if the difficult task of digging a pit and the slow repayment of the investment are taken into account.

The only possible way of using compost might be in an intensive gardening system near a watering point. The compost could be made on the spot and it could increase and sustain the productivity of highly valuable (cash) crops. The basic materials could be a mixture of vegetable waste and manure. The compost could be used alongside chemical fertilizers specially to improve the structure of the soil.

If people in Mvumi would ever start making compost they might do it at their homestead and it is not unlikely that women would be heavily involved in collecting the organic material and water. If it would be linked to intensive gardening this would be a man's job.

Other Criteria
The technique as such seems simple but it only works when it is done properly. Just throwing some organic matter in a pit will not be usefull at all. Training would be needed.

Composting requires a lot of labour. First the digging of a pit. The soil in Mvumi is usually very hard, specially in the dry season when people could spare some time to make a pit. The second problem is the collection of organic material, the cutting of the organic material in small pieces and collecting water. The water (2.5 litres per kg of compost) will most of the time be the biggest problem, resulting in too little water and a poor composting process. The school in Chanhumba has tried to make compost, but although they managed to make it they stopped after some time. The pits are still there but the teachers say that it is too much work (even with 'free' labour of the schoolchildren).

It can (better: it needs to) be integrated with both intensive livestock keeping (for the manure) and with intensive crop production, most probably intensive gardening.

Conclusion
Like with the other organic manures it is economically not attractive. The high water requirements make it unlikely that it will become more attractive in the future.

10.2.4.3.5 Conclusions

The long term effects of organic manure are not to be doubted and are well understood, also by farmers, but their economic returns are too low. A general problem is the long time between the investment and the return. Usually it will take one or two years, far too long for a poor farmer who possibly has a planning horizon of a few months or even less.

Another general problem is that working under any amount of organic matter is very difficult, due to the hard soils. For greenmanuring an extra problem is the non-availabilty of land and for composting the high water requirements are prohibitive.

Seeing the already low price of labour in Mvumi it is not likely that the economic parameters will chahge enough in the (near) future to make the above discussed innovations attractive.

10.2.5 Mechanisation

Introduction
Seeing the overpopulation of the area, in the future the heavy 'mbuga' soils (2%) will be needed for food production, either via crops or via animals. Indeed slowly people start to cultivate small plots in the mbuga's (specially in Mvumi Mission) and they do some digging in the dry season. However this is a tough job and mechanization, either by tractor or by animal traction, is the often advocated solution.

Pre-conditons
Ecologically seen mechanisation has brought quite some troubles to Africa. It often leads to a more extensive pattern of cultivation instead of the needed intensification. This has tree major reasons: first the area cultivated is extended beyond the capacity of the farmer to weed it properly. Secondly as a result of the expansion of the area more marginal soils are cultivated, leading to erosion problems. Lastly the quality of ploughing often leaves a lot to be desired. The result is that with oxenisation the area under crops is increased considerably (25-30%) while the production per acre increases on average slightly (5-10%), but with a lot of differences: sometimes it increases, sometimes it decreases (Holtland, 1988). For tractorisation no data are available but in principle this will be the same. In Mvumi an extension of the area under crops is not possible nor desirable so all investments have to be recovered by higher yields per acre. The only exception being the mbuga soils.

Economically seen tractors are too expensive. A price of about 8.000 Tsh per acre seems necessary to run a tractor commercially. Digging with a hoe costs between 2 and 3.000 on non-mbuga soils and for mbuga soils it might be 4 to 5.000 Tsh.. The local available tractors which are owned by villages plow for 5.000 Tsh. (1993/94) and the only privately owned one costs 5.500 Tsh., but the owner does not like to plow because it brings less money than other activities and in practice he only ploughs very few fields. With the ongoing liberalisation policy of the GOT the ratio between prices of tractors and human labour will increasingly become more unfavorable for tractors.

Another major constraint is that ploughing can only increase the yield if the planting is not too much delayed. So on the big fields ('migunda') it can only be used for a very short period after the first rains, after this they can still be used shortly on 'vigundu' fields, mostly groundnuts.

There is no need to explain here the many advantages of oxenisation above tractorisation, but unfortunately also oxenisation is no option for Mvumi. The basic reason is the same: the rainy season is too short to first plow and then sow. Usually dry planting gives the best yields or digging and planting should be finished within a week after the first rains. This means that the oxen can only during a very short period give increased yields. After that it can still be used for a short period on groundnut fields ('vigundu'). All overhead costs of the oxen, the equipment and the training can not be recovered in such a short period without raising the prices far above the price of hand hoeing.

An additional problem for oxen compared with tractors is that the quality of their work is poor. Many soils in Mvumi dry out very quickly and become very hard, already one week after a shower an oxplough can only scratch the soils.

In general in Africa it was found that the workload of women is increased after the introduction of ox-ploughs: the men profit from the easier and quicker land preparation while the women are responsible for weeding a much larger area (Holtland, 1988). In Mvumi this is not likely to be the case as men and women do the digging and the weeding together.

Other criteria
It is often stated that the Wagogo do not adopt oxenisation because they do not want to hurt their animals. This seems not to be true. In Mpwapwa many Wagogo use their animals for ploughing and farmers in Mvumi often deny this reasoning. It seems more an explanation which is liked by officials (among them many non-Wagogo) who fail to understand the rationality of the farmers refusing oxenisation.

History proves that despite many efforts to introduce ox-ploughing in Dodoma (f.e. via centres in Bihawana, Ipala and Kigwe), no adoption has taken place. Also in Mvumi there are people who are trained to work with oxen and ploughs are available in nearly all villages (they were given as a present), but nobody practices it. In the 1993/94 season an innovative farmer ploughed his own groundnut fields with oxen but failed to hire them out to others.

10.2.6 Soil- and water conservation

The innovation
Since the destocking erosion on fields is no longer considered a problem by the farmers and it seems they are right. As such erosion is not mentioned as a major constraint in chapter 9. However it remains to be seen whether this positive effect of the destocking is permanent or temporally. It is clear that the area is overpopulated and that only the relatively strong presence of HADO prevents clearing of larger marginal areas on hills. So for the future it is still good to describe the (im)possibilities of soil- and water conservation measures. Here only contourbunds are discussed as it resembles very much the above discussed labour intensification of the crop production. Tree planting and agroforestry, which both also have a soil conservation aspect, are discussed later.

In Mvumi rains comes in heavy poordowns and many times the amount of water coming down during a shower can not infiltrate instantly in the soil. So the water starts to run off and with it soil particles. In this way gullies can develop on (upper and lower) pediment-slopes and sheet erosion occurs in the lower pediment or valleys. Contourbunds can prevent this. A contourbund is a trench (with a ridge of soil on the lower side) laid out along the contour. When rainwater starts to run down from a slope it enters the trench and when the trench is overflowing the water is stopped by the ridge of soil. As both are laid out along the contour water stays stagnant and infiltrates in and around the contour.

In order to control erosion completely a catchment approach is needed as the problems start on the hills. A catchment approach means that the whole community needs to cooperate. It also needs a very high level of awareness of erosion problems and a strong leadership of the community. Both are not found in Mvumi at the moment. So here only on-farm contourbunds are discussed which could prevent erosion on individual fields as long as not too much water is coming down from the hills. If at some time in the future the erosion problems become so big that a catchment approach is needed much attention should be given to the balance between local techniques of diverting run-off and 'imported' techniques to stop runoff completely. As described in 5.4. farmers do modify the run off but not always with the aim of completely stopping it.

Pre-conditions
From the description it is clear that a reduction of erosion will improve the sustainability of the farming system substantially.

In 1992 the MRTC paid 15 Tsh per meter of contour. The trench was 1 foot deep, 2 feet wide at the top and 1 foot wide at the bottom. In this way 4,200 Tsh. is needed per acre (70 m long, 60 m wide and a contourbund every 15 m). Most farmers do not have 4,200 Tsh cash, and if they had they would not easily invest it in contours which will start to pay off after a long time. Making one contour per 15 meter means that roughly 6 to 7% of the area gets lost for crop production which needs to be compensated by a higher production per square meter elsewhere. If it is assumed that the contourbund has a positive effect from 2.5 meter above its contour to 2.5 meter below, than this 5 meter should produce 20% more than normal to compensate for the loss. Another profit could be obtained by growing some high water demanding crops on top or at the bottom of the ridge, f.e. Elephant grass (which has the extra advantage of stabilising the ridge) or fruittrees (f.e. guava).

On the MRTC demonstration plot no clear yield increase is observed near the contourbunds. Possibly the water conservation is not very big on sandy soils which have a limited water storage capacity.

These tentative conclusions are in line with the little enthusiasm of the farmers who made some contourbunds in the past. The colonial administration forced farmers to make contours on their fields. An old man in Mvumi remembers that he did so (together with others), but when they were silted up they did not repair them as they did not see any postive effect of it. In the 1980's some farmers tried it again, this time with HADO. They also state that they would not do it again as it was too much work which was not repaid.

As these conclusions seem contradictionary to what is believed to be the case in other areas, some more explanation is given. If the economics of contourbunds in f.e. Arusha are compared with those in Mvumi many major difference occur:

- in Mvumi most of the fields are (rather) flat, cultivation on hills is forbidden by HADO;
- the destocking reduced the erosion tremendously;
- in Mvumi it only rains once per year, so the possible profit is only gained once per year;
- the soils in the dry season are very hard, so digging a trench is very laborious;
- the extra yield from a contour may be relative high in some years (due to the water conservation effect) but in absolute terms it will always be very small compared to other areas.

So finally it may be more attractive for a farmer from Mvumi to dig a contourbund in Arusha as a daily labourer than making one on his own field.

As the work of making the bunds is done by men while the women will profit from the assumed yield increase, the innovation would have a net positive effect on the position of women.

Other criteria

The water conservation of the contours makes it possible to get higher yields in years with poor rains. In Mvumi this has not yet been observed. There is a small risk when bunds are not laid properly along the contourline. In that case the erosion might increase as a lot of water starts to flow along the contourbund. It might break through at a certain point and develop into a gully. With some training however this can be prevented.

The principle is simple and well understood by farmers. However to measure the contours needs quite some training initially, f.e. with the A-frame. Once the practise is established there is no need for further support.

The labour requirements are very high, per acre at least 20 mandays are needed (assuming 4 cubic meter is moved per manday) or at least one month. Again, this is hard working. A positive point is that no capital is needed. Still it will be a bias to better of farmers because of the long term investment needed (in terms of labour or paid labour).

As the bunds offer good possibilities to grow fodder and trees which usually need more water than normally available, it would have positive integration effects.

Conclusions

In discussions with farmers it is clear that digging a trench is problematic to them, also as they don't see erosion anymore. Few estimates on the economics of contours underline this. Some farmers say that making small ridges in their fields might be possible and helpful. If they are made close enough to each other and if they are really on the contour this might be true and it seems worthwhile to try it sometimes. It is also a practice with resembles a bit the local practice of water conservation as described in chapter 6. The small ridges could be used for the cultivation of sweet potatoes.

In the future contourbunds might become more necessary when people start clearing marginal areas on the hill slopes (see also 10.4.4).

10.2.7 Intensive gardening

Not much is known yet on the technical aspects of the production, but as the amount of money earned with it is large there seem to be possibilities to increase the productivity. One option could be the use of some pesticides. Possibly fertilizers or compost can increase the production also, in practice some people already use chemical fertilizer and pesticide.

Next to the large amounts of cash involved another major advantage is that there is a big market. Most is sold in Dodoma, where a lot is again transported to DSM. It seems that a good market is secured, also in the future.

10.3 Improvements in the livestock system

10.3.1 Improving the feeding strategies of the zero-grazed cows

10.3.1.1 Introduction

As the climate, the disease pressure and the genetic potential of the cows are not limiting factors in Mvumi, improving the feeding of the cows is the major challenge for the future. The present strategy of farmers is to invest as little cash as possible and to make optimum use of abundantly available (=cheap) local resources (labour and biomass). Within this basic principle some improvements are possible:

1. early harvesting of crop residues;
2. proper storage of crop residues;
3. using dual purpose crops like pigeon pea and lab-lab;
4. use more green feed, f.e. of leguminous shrubs;
5. cultivation and pressing of sunflower;
6. use more maizebran.

All these principle are fairly well known to the farmers in Mvumi and most apply some of them and the MRTC is encouraging them in improving on this. Slowly progress is made. This dry season (1994) some farmers store a fairly big amount of fodder and others buy maizebran at a high price which was not done some years ago. Here they are not discussed in detail, only the use of sunflower cake is shortly explained before some more detailed attention is given to stripping and topping of cereals (i.c. maize).

Sunflowercake
The possibilities of sunflowercake are interesting. Shayo (1992) reported that with a price of 45 Tsh. per kg and a milkprice of 80 Tsh./l. this can be used profitably. In Mvumi handpresses could be introduced which make the cake available at a much lower price (15 Tsh./kg) while the price of milk is 100 Tsh./l.. This makes the use of the cake more attractive than grounded Acacia seeds as advocated by Shayo, the more as it also provides the farmers with cheap cooking oil. For more information see par. 10.2.2

10.3.1.2 Stripping and/or topping

Introduction
A special way of early harvesting of crop residues is stripping and/or topping. This means that part or all of the leaves of cereals are removed before harvesting the grains. Shirima (1994) reported that in Mpwapwa this is possible without any yield losses. As this seemed an important conclusion a Dutch student initiated a similar trial at the MRTC. The MRTC did the stripping and the analysis.

The trial was a completely randomised block design with four treatments and three replications. The maize variety TMV-1 was used, this is a medium term variety (100 days). As one replication produced two outlying values it was decided to leave it out completely in the analysis.

The treatments were:
1. harvesting the fodder after the normal harvest of the grains (115 days after planting);
2. stripping: removal of all dead leaves 75 days after planting (about 10 days after 50% silking) and of all the leaves below the cob on 90 days after planting (about 10 days after 50% milk stage);
3. topping: removal of the top of the maize (above the cob) 90 days after planting;
4. stripping and topping: removal of the dried leaves below the cob 75 days after planting and stripping the remaining leaves below the cob 90 days after planting when it was also topped.

Pre-conditions
Stripping and topping reduces the amount of organic matter decomposing in the field. It also leaves the field more open to wind erosion. On the other hand the manure resulting from it can be returned to the field.

On the economic side of course the effect on the grain yield is most important. This can be seen in the table 19.

Table 19 Yields of total biomass, grain and fodder in the stripping/topping trial

treatment:	normal	stripping	topping	stripping + topping	LSD (5%)	CV (%)
total biomass	3.852 a	3.998 a	3.129 b	3.731 ab	720	8
grain yield	1.289 a	1.408 a	986 b	906 b	253	7
fodder yield	2.180 a	2.193 a	1.857 a	2.516 a	753	11

Treatments with a similar letter or not significantly different from each other.

Source: MRTC data

In the table it can be seen that only stripping does not have any negative effect on either the grain yield or the total biomass yield. Topping however reduces the grain yield with 30% and this loss is statistically significant. The combination of topping and stripping does not differ from the topping indicating again that stripping is harmless. As the quality of the different types of fodder is not yet determinated nothing can be said about this, only that a better quality of the fodder will never be able to offset the loss in grain yield.

These results deviate much from those reported by Shirima (1994), specially as the maize variety used there was 'Staha' which has a longer growing period (120 days) while the stripping and topping was done earlier. Still no negative effects on the grain yield were found. Possibly the large amount of fertilizer used had an effect on this or possibly the rains were still going on at the time of stripping and topping while in Mvumi it hardly rained in that period. Whatever the case the differences are hard to explain.

During the trial the time needed to harvest the biomass was measured and compared with the time needed to cut natural grasses, which is the normal farmers practice at the end of the rainy season (March/April). It was found that stripping takes 11-14 minutes per kg of air dry matter. This can not compete with cutting grasses which takes only 2-3 minutes for the same quantity. Topping is as quick as cutting grasses. Harvesting the whole stalks immediately after the harvest is the quickest method of getting fodder, if it is however assumed that the cows discard the hard stems the time needed for harvesting the leaves is equal to cutting grasses.

The effect on the position of women are unknown as it is unclear whether this would be a task of men or women.

Other criteria
It is an innovation which will be easily adopted if economically viable. Some farmers do some strip leaves near their homestead if fodder is urgently needed and they do not have time to collect it from far.

10.3.2 Preservation of manure

Introduction
As N is the most limiting factor in the farming system, its fate under different manure-management regimes is crucial for the sustainability of the farming system. Here a comparison is made between several systems of handling the precious N in manure: traditional kraals, open manure heaps, composting, biogas and deep litter stables. Most data in this section come from the excellent proceedings of a workshop on 'Resource efficient farming methods for Tanzania, May 16-20, 1983" (Semoka et al, 1983).

N-conservation
The essence of proper manure handling is to prevent N from volatilization and denitrification. Volatilization takes place in aerobic conditions and means that N from proteins is converted into NH_3 which is a gas and disappears in the air. It occurs when the organic matter in which N is fixed has a C/N ratio of less than 25 and when it is wet (so biological active). A high temperature and a neutral or alkaline pH are favorable for this process. Denitrification takes place under anaerobic conditions and means that org. N is converted into N_2 which escapes as a gas.

Of all N taken up by cattle about 4-14% is retained in the body for production (of milk and meat). The remaining is secreted, either as manure or in urine. Commonly about 50% of all N is excreted via urine and 50% via manure. This makes the use of N from urine crucial in N-conservation.

The traditional way of leaving manure in an open kraal for a few years is inefficient in terms of N-conservation. A study in Tanzania found the N-content to be in the order of 0.65% while when it was made in a covered yard is 1.5% (Kasembe et. al., 1983). In Makangwa the present author found an average of 0.5% N in 8 samples of kraal manure of different ages. On the other hand the long term process of composting/trampling makes the organic matter fairly stable when it is taken to the field so the maximum positive effect on the structure of the soil is reached with the minimum of transport costs.

The zero-grazing farmers in Mvumi stack their manure on open heaps. The N from the urine does not reach the heap. The feces do, but as it is not protected from rain and strong winds, losses are considerable. An experiment in Ghana started with manure with 1.74% N. When stored for 3 months in a loose heap 59% of the N was lost. When stored in a compact heap 47% was lost. When in was burried in a pit only 15% got lost (Kwakye, 1980). The present author found on average 0.65% N in 8 open manure heaps of zero-grazing farmers. A simple shade would reduce the losses considerably. Borowski and Liebhart (1983) showed that the N-loss in a weather-thight shed was 23% after one year while it was 40% in a box which stood outside. So compared with an open heap from Ghana the box itself reduced the losses considerably and when isolating it completely from weather influences it was even further reduced. A simple shade might reduce the loss form 60% in 6 months to 40%.

Also in the process of making biogas quite some N gets lost. First of all no N from the urine is included, so half of the N is not included. Secondly some N gets lost during the process. In the digester hardly any losses occur, but the protein N is converted into ammonium and nitrate. When this is pushed into the expansion chamber, part of it will get lost (how much will depend much on the pH of the solution, but as a healthy plant has a pH of 7, much N will escape). When it leaves the chamber and flows into the open air this process is speeded up and large losses may be expected, specially in Dodoma with its high temperatures, neutral soils and strong winds. The present author found (with two plants) losses of over 50% in slurry of a few weeks old. So it can only be used optimally when it is quickly worked under (f.e. in a vegetable garden). In practise it often just flows out of a plant and dries up.

An alternative is composting the manure. Also in that case the urine and its N would remain in the stable. The manure would be taken out and placed on a heap or in a pit. Seeing the dry climate a pit is the best. Borowski and Liebhart (1983) report that during the composting of farm yard manure after 2 months 5% of the N was lost, after 4 months 14% (similar to the compost pit above) and after 12 months 24%. Major advantages are that the amount of manure is reduced and the quality increased. Major problems however would be the digging of a pit and the adding of water which would be needed for getting a good composting process going (see 10.2).

The last possibility is a deep litter stable. In this case the cow is confined to a somehow smaller area and all refused fodder and even more organic materials are added. This has the big advantage of conserving the urine and its N which is used to compost the refused fodder and other low quality organic material. Next to that the N from the manure would be better conserved (as in composting in a pit). It would lead to a higher total amount of manure with a higher N content. If enough org. matter is added no health hazards are to be feared, specially as Mvumi is a dry area with relatively few diseases.

Based on the above a model calculation can give us some insight in the N-cycle of a cow of 400 kg under different manure management systems: the N-intake is 3% of LW/day of fodder with an N-content of 1%. So per year 44 kg of N is taken up. Of this 6 kg is retained and excreted as milk (1,200 litres with 0.5% N). The remaining 38 kg is excreted: 50% via urine and 50% via feaces. So in both cases 19 kg. Table 20 gives a guess of how much N would be available from this cow under the different management systems.

Table 20 Effect of different methods of handling manure on the availability of N

method of handling manure	input of N (urine/feces/straw)	% lost in storage (6 months)	% lost in applying the it	total amount of N available
kraals	19	60	5	7
open heap	30 (*)	60	10	9
shaded heap	30 (*)	40	10	15
biogas	19	10	50	8
composting	41 (**)	20	10	29
deep litter	60 (**)	20	10	42

(*) 11 kg of N is added via the refused fodder added to the open heap

(**) 22 kg of N is added via the refused fodder and some extra low quality org. materials added.

Source: see text and some estimates by the author

A major difference between the kraal and the other systems is that next to the manure in the kraal the same amount is available in fields and in the grazing areas (7.2.6.4.). In the table it is assumed that the amount of fodder offered to the cows is 1.5 times as much as actually consumed. This refused fodder has an N-content of half of the eaten fodder (=0.5%). This gives 11 kg of N extra in the stable. As this fodder is not enough to make the stable clean and dry another equal amount is added which can be any dry organic material, containing another 11 kg of N.

Deep litter stables appears superior in terms of N-conservation. Also composting performs well. Biogas performs similar to than kraals and open heaps, but in this case it depends much on the timing of applications. If it is worked under immediately after it leaves the expansion chamber it will have less losses then estimated here. If this is delayed (a few months or more) the losses during application are even higher than assumed here.

The economics of N-conservation

As no labour data and other economica data are available, for the time being the different systems can only be compared with each other on the base of some qualitive reasoning. The only significant comparison is between the present practice of open heaps and the alternatives of a shaded heap, biogas and a deep litter stable. The kraal is not used anymore in Mvumi and composting is too expensive because of the water requirement (see 10.2.4.3.4).

Biogas and the open heap do not differ in the amount of available N. The economics of biogas are discussed extensively in the next paragraph. A shaded heap saves 6 kg of N, which if applied well might in lead to an extra yield over a few years of 90 kg of grain. This gives an extra income of 3,600 Tsh. per year which seems enough to try it.

A deep litter stable yields about 33 kg extra N compared to an open heap. This gives an increase in grain yield of 500 kg, equal to 20,000 Tsh./year. This seems a lot compared to the extra costs. The extra costs (compared to the actually used open heaps) is the time to collect extra (low quality) organic matter for the bedding of the animal. On the other hand the daily cleaning of the stable can be less, saving about 15 minutes per day. No extra costs are incurred in the stable as it must be simple to design a stable with local materials which is as cheap as the existing structures.

So of the three options the shade and the deep litter stables should be tried out in practice to see their appropriateness. Biogas does not seem attractive from a N-conservation point of view but it has its own strong points which are discussed next. In any case the use of carts should be encouraged to reduce the high labour requirements for the distribution of manure to fields.

10.3.3 Biogas

Introduction
Biogas is a rather new technology for Dodoma. It is promoted by a special NGO: MIGESADO (Miradi ya Gesi ya Samadi Dodoma) which assists farmers with technical knowledge and a subsidy. It also trains local artisians to construct a biogas plant. In Mvumi the MRTC is facilitating the MIGESADO activities. Until present one local artisian is trained in building biogas plants and four farmers are preparing themselves to construct a plant.

The major aim of biogas is to convert part of the manure into biogas which can be used for cooking and lighting. In the first case the use of firewoood is reduced and in the second the use of expensive kerosine.

The production of biogas is based on a natural activity of bacteria under anaerobic conditions. Basically organic matter from manure is kept in a watery solution and fermented. In this process organic matter is reduced to CH_4 which can be burned in appropriate burners for cooking or lighting.

Major determinants for the amount of manure needed and the amount of gas produced is the ambient air temperature. In Dodoma this is quite favorable with an average monthly mean max. temp. of 29°C and min. temp. of 16°C.

Biogas digesters can be built in all sizes, but for Dodoma between 8 and 16 cu.m. are most appropriate. The one of 12 cu.m is mostly used. It provides enough gas for cooking (three times per day) and two lights in the evening.

Any amount of manure can be added per day. The more is added the shorter the retention time (RT) and the lower the gas production per kg of manure. However as more manure is added the total gas production will rise. The added manure should have a DM (or TS) content of 7-11%. As fresh manure has a DM content of about 15-20%, it needs to be diluted with an equal amount of water. As water is scarce in Dodoma the best option is to reduce the manure added per day and increase the retention time. However there is no use in a retention time of more than 300 days which means that the minimum amount of daily fed manure should be 40 litres, equal to one bucket of manure and one of water. If the added manure has a water content of 10% than 4 kg of DM is added per day. This can be expected to produce about 1,560 l of gas daily. If 2 buckets of manure and two of water are added the retention time would be 150 days and the daily gas production would be 2,320 l./day. This makes the second bucket of water less economic than the first. Indeed the present advice of MIGESADO is to use 1 bucket of manure and 1 bucket of water daily.

In principle the amount of water can be reduced slightly if the urine of the animal is added. In practice this seems hardly feasible. Very few farmers have a concrete floor. If they have one, it is usually rather large, so the urine can not be collected easily. It usually dries up before it has reached the outlet or the cow drinks its own urine again.

The 4 kg of manure needed to keep a 12 cu.m biogas digester running can be provided by one improved cow, if kept on zero-grazing. F.e. an animal of 400 kg would have a DM intake of 3% of its bodyweight of which 50% is digested. This gives a manure production of 6 kg. DM/day, so one third can be spoilt without problems. For local cows which are grazed, about 6 seem enough. However in both cases the initial filling can be problematic as about 6 cu.m (or 2 lorries) of fresh manure are needed. The problem is that only fresh non-contaminated manure can be used.

Pre-conditions

As the innovation reduces the use of firewood it contributes to the ecologically sustainability of the farming system.

The costs for running a plant comprises of the following (data taken from an internal memo from the MRTC to MIGESADO, some are slightly modified):

Investments	
a. initial investment for building:	250,000
b. initial filling (5 cu.m water and 5 cu.m manure):	10,000
Depreciation	
c. depreciation (26 years):	10,000
Running costs	
d. maintenance and repair (socks for gaslamps etc.):	1,500
e. labour (20 min./day= 122 hours x 30 Tsh./hr):	3,660
f. manure and water:	7,300

Ad f: a bucket of water is taken to costs only 20 Tsh.. or 7,300 Tsh/ year. The manure is supposed to be free as it contains as much N as the 'normal' storage method of open heaps.

So the total investment is 260,000 Tsh., the depreciation is 10,000 Tsh./year and the running costs are 12,460 Tsh./year.

The gas resulting from these investments and running costs can be used for the following purpose (data from GTZ booklet on biogas):

- 2 lamps for 2 hrs. (7 - 9 p.m.):	600 l./day	(150 l/hr/lamp)
- tea in the morning	200 l./day	(400 x 0.5 hr)
- afternoon meal	300 l./day	(400 x 0.75 hr)
- evening meal	400 l./day	(400 x 1 hr)
Total consumption:	1,500 l./day	

This consumption is in balance with the gasproduction as mentioned above. In this example not all cooking is done on biogas. People day that for long, slow processes like cooking beans (but also water) they use charcoal or firewood in stead of biogas. It can be seen that a third lamp makes three cookings per day impossible. A last remark is that in the cold months of July-Sept. gas production is less so the consumption must sometimes be adjusted.

In this example the amount of firewood for cooking which can be saved is 5 kg./day or 1.5 kg of charcoal. Per month this saves 150 kg of firewood or 45 kg of charcoal. This equals 5 bundles of firewood or 1.2 bag of charcoal.

No comparable data for lamps are available. Only that one user saves 3 gallons of kerosine per month by using three biogas lamps. Here it is assumed that two lamps save two gallons of kerosine per month. This assumption needs to be tested as it is crucial to the whole economic picture.

The total saving is 60 bundles of firewood per year (or 14.4 bags of charcoal) and at the max. 24 gallons (2 gallon/month) of kerosine. The prices are resp. 200 Tsh. and 900 Tsh. in Mvumi. So resp. 12,000 and 21,600 Tsh would be saved per year. In total this is 33,600 Tsh./year.

So the net saving would be 11,140 Tsh./year from an investment of 260,000 Tsh. This gives a return to the invested capital of 4%. For a large cash investment this is low. On the other hand it is a positive result.

Of course this is just a model calculation. A first remark is that labour is the major running cost, and collecting water is the major component of the total labour requirements. A change in the availability of water is crucial for the whole economics.

A second problem is the assumption that 2 gallons of kerosine are saved per month. This is not likely to be the practice as the fast majority of the households do not even use one gallon of kerosine per month. So in practice the advantage of the lamps is to add to the comfort of people and to keep them awake longer, making their time more useful. Also a lamp can not replace kerosine lamps completely, as they are not mobile. This is a severe handicap to the above calculation. If only one gallon per month is saved the return to the capital invested drops to nil. This makes the innovation more attractive to semi-urban households who's members like to read in the evening (and where firewood is also expensive).

More problematic from the point of view of prevention of the natural degradation is that saving kerosine is more attractive than saving firewood. In the present analysis 65% of the saving comes from the lamps who use only 40% of the gas. If biogas would be only used to replace firewood the returns to the capital would be slightly negative, making it economically un-attractive. A second advantage of replacing kerosine is that it saves cash, while replacing firewood 'only' saves labour. Indeed the first experiences of MIGESADO are that the users of the first plants ask for more lamps and less stoves.

In the future it seems likely that the prices of kerosine and the building materials for the plant become relatively more expensive than firewood, making the economics of replacing firewood by biogas even worse. To be able to detect this all prices must be closely monitored.

The beneficiaries of MIGESADO pay only part of the investment needed. Depending on their capacity to pay they contribute between one third and one half. The return to their investments is two to three times higher than the economic returns, so it is between 10 to 15%. This seems reasonable but is still not high seeing the relatively high investment at once and the fact that part of the 'saving' is extra consumptions.

As women are responsible for the collection of firewood they are the first beneficiaries of the innovation together with school children who are able to read and study comfortable in the evening. Women do not only save time in not collecting firewood they also cook quicker. This however can be a disadvantage as they can not anything while cooking (otherwise the food gets burnt). A last advantage is that biogas does not produce smoke like firewood does.

Conclusions

Biogas has several intrinsic positive points, both ecologically and socially (in terms of improving the position of women). The only problematic aspect is its economics. Too little concrete information is available on the actual price of a biogas plant, on its labour requirements and on the actual amount of firewood and kerosine it saves. Therefor while the building of plants on a pilot base continues some monitoring of prices and farmers practices should be initiated.

10.3.4 Institutional improvements on zero-grazing

These issues are no real innovations and they are just mentioned here for completeness and to show that agricultural development is not only technical but has also a big institutional component which is very important, specially in the case of completely new technologies as zero-grazing.

Monitoring

To reduce the long intercalving period it is necessary to develop a monitoring system via which all cows are closely supervised (by the farmer, the VEW's and the MRTC staff). Breeding calendars at farm level and pregnancy diagnosis are of utmost importance. The aim should be to reach an average of 15 months.

Marketing

Slowly marketing is becoming a problem and the farmers and the MRTC should discuss the possibilities of selling the milk in Dodoma (see 7.3).

10.3.5 Improved veterinarian services for non-ruminants

The only possible improvement (next to perhaps intensive poultry production for Dodoma town) in the near future will be the prevention and curing of pests and diseases (better housing, worms). In particular the problems of worms in pigs and the New castle disease of chicken could be adressed. In the last case a new vaccin which can be stored at room temperature would be very helpful.

10.4 Improvements on the tree component of the farming system

10.4.1 Introduction

Although it is difficult to come with hard figures about the shortage of wood in the area (see 8.2) it is clear that the natural vegetation of Mvumi can not supply enough wood for the population in the future. So trees have to be planted and the existing natural vegetation has to be managed better. Three option are discussed here: agroforestry (alley cropping and dispersed trees on farm land), planting trees outside the fields and improved management of the natural vegetation.

10.4.2 Agroforestry

10.4.2.1 Introduction

In agroforestry woody perennials are deliberately used on the same area as crops and/or livestock. As such it is a very common farmers practice, but since the 1980's it has attracted a lot of scientific interest as it is thought to be able to make agriculture more productive and more sustainable at the same time. There are many forms of agroforestry, these days even shifting cultivation is considered to be agroforestry. Here only the simultanious production of crops and trees on one field are considered. Two options are discussed: alley-cropping and leaving more trees in fields at randomly.

10.4.2.2 Alley cropping

The innovation
Alley cropping is one of the best known types of agroforestry. It consists of rows of trees/scrubs in between crops. The trees are lopped (pruned at a somewhat higher level) every now and then. Mostly the leaves and small twigs are left in the fields so that they act as a mulch and improve the soil structure and fertility. It is however also possible to feed them to livestock. The bigger pieces of wood are mostly used for firewood.

In Dodoma a few environmental projects are or have been promoting alley-cropping in the last ten years (a.o. HADO and DOVAP). However at the time the MRTC started its activities non of them could produce convincing evidence that it was an economically sound practice. So in 1990 it was decided to do an on-station trial to asses this. Data of 4 seasons are available (from the 1990-91 season till the 1993-94 season).

The trial was a completely randomised block design with 4 replications and 4 treatments: two alley cropping designs and a control plot. The tree used was Leuceana leucocephala. One design was a single row of Leuceana after every 6 meter. Between the scrubs was 1 meter. The other design was a double row of Leuceana every 6 meter, whereby the trees were planted zig-zag at a distance of 0.5 meter. The first treatment is refered to as LS (Leuceana single) and the second as LD (Leuceana double). On the control plot cereals were grown continiously as is the most common farmers practice. The cereals were planted at 75 x 25 cm. In the first two years sorghum was used (Tegemeo) in the third year millet (Serere) and in the fourth year again sorghum (Tegemeo).

Preconditions
Alley cropping contributes to the sustainability of a farming system in many ways. Its major aim is sustaining the soil fertility of the cropped area. It is thought that the tree component of the system can pump up nutrients for deeper soil layers where roots of crops do not reach. If the tree is leguminous it could also add N to the system by N-fixation. To check these assumptions in Jan. 1994 (two weeks after the onset of the rains of the fourth cropping season) soil samples were taken. Table 21 gives the results.

Table 21 Effect of 3 years of alley-cropping on soil fertility

	pH-KCl	org. matter (%)	N-total (%)
Initial value (1991):	6.0	0.65	0.07
control (1994)	5.3	0.60	0.06
alley-cropping (1994)	5.6	0.72	0.07

Source: MRTC data

Table 21 shows that with alley-cropping the organic matter content of the soil improved while total N remained the same (at least when the figures are rounded of). The pH is slightly lowered during the 3 cropping seasons. It seems indeed that the soil fertility is sustained, at least far more sustained than in the control plot where continous cropping was practised. In this control plot the pH is considerably lower, and about 10% of the org. matter and N are lost in 3 cropping seasons. Unfortunately, the data from table 21 are only indications as the 'initial value' (from 1991) is only based on (composed) samples per replication and not per treatment.

The row of trees can form a physical barrier to run off water and so to soil erosion. Secundly the canopy of the trees and the mulch it produces cover the soil better and so prevent erosion. This last effect is generally far more important than the physical barrier effect (Young, 1989). The row of trees is an effective way of preventing wind erosion.

Of course the firewood from alley cropped fields reduces the pressure on the natural vegetation and as such contributes to the sustainability. The 200 kg/ha of firewood (as mentioned later) is equal to about 0.3 cu.m. of wood.

If all fields would be alley-cropped this would yield 0.12 cu.m. of firewood per capita or about 12% of the estimated consumption.

On the economic side the yield of the cereal is the most important factor. The next table shows the yield of the different treatment over the first four years of the trial. In this case the Leuceana plots were taken as one treatment as they did not differ among themselves.

Table 22 Yields in the alley-cropping trial (kg/ha)

	1991	1992	1993	1994
Leuceana	2,374*	1,066	1,024	2,552
control	2,366	1,308	1,125	2,152
P	n.s.	1%	n.s.	1%
CV	10%	2%	6%	3%

* one outlying value denied

The first remark about the data should be that all yields are far better than the average yields on farmers fields. This is due to the better management and shows again that this is the most important factor in crop production. The table shows that in the first year the yield with and without Leuceana is equal. This is a good performance for the alley-cropped plot as 12.5% of the area is occupied by the trees. It seems that the rows bordering the small trees used the extra light they received very well. In the second year a severe water competition between the crop and the trees was observed and the total yield of the alley cropped plot was 19% less than the control plot.

In the third year the first positive signs of the effect of the mulch from Leuceana became visible. At the same time however the water competition reduced the yield in the rows next to the trees. In order to asses the magnitude of both effects the rows next to the trees were harvested seperately.

Table 23 Yield of different part of the alley-cropped plot as a percentage of the yield of the control plot

part of the plot	treatment	1993	1994
rows next to trees	Leuceana single	85	155
	Leuceana double	81	142
rows in the middle	Leuceana single	109	155
	Leuceana double	113	135

Source: MRTC-trial

When reading the table one should realise that in 1993 the watercompetition was very severe during a few dry spells in January-February. In 1994 the rains went on from January till the beginning of March without any problem.

Table 23 shows that in 1993 the negative effect of watercompetition was bigger than the positive effect of the organic matter from the trees. As might be expected, both the watercompetition and the effect of the organic matter is bigger in the plots with a double row of Leuceana than with a single row.

In 1994 all factors were in favor of the alley cropping plot. First the organic matter from the trees went on accumulating. Secondly the rains delayed but when they came it rained continuously for over two months, enough for the Tegemeo to yield very well. Thirdly the Leuceana psyllid kept the Leuceana small until April, so the Tegemeo by-passed the lopped trees and used the extra light available. So surprisingly it seems that the psyllid is a positive factor in alley-cropping in Mvumi as it is only active in the wet season to reduce the competition for water and light, while in the dry season the Leuceana can produce the necessary biomass. So in 1994 the rows next to the trees yielded more than the rows in the middle of the plot. As also the middle of the plot was better than the zero-plot in total the alley-cropped plot yielded 19% more than the control plot.

In general table 22 and 23 make clear that alley-cropping yields better in years of favorable rainfall and less in years with poor rains. This will be even more so on most of the farmers fields as the present field has a fairly high groundwater table. This keeps the Leuceana reasonably productive in the dry season and reduces the watercompetition in the crop season.

Of course the alley-cropped plot has the extra yield of firewood. In 1994 the dry weight harvested at the end of the dry season from the plot was measured. It came to nearly 200 kg/ha. After drying it had an estimated value of 1.000 Tsh.. This is lower than for normal firewood as it's quality is considered very low by the women. They said they can only use it for beer brewing. Another problem is that it is fresh so it needs to be dried for a long period while it becomes available at the beginning of the wet season. The second pruning (5 weeks later) hardly yields firewood.

A second major factor for the economics of the innovation are the labour costs. Compared to the control the alley-cropped plot needs more labour. First the planting of the plot costs at least 10 mandays/ha, or 2,500 Tsh. Secondly clearing the field is more difficult as burning crop residues has to be done very carefull, otherwise trees might catch fire. Also planting has to be done exactly on line otherwise too much space gets lost to the trees.

Thirdly the pruning of the trees. The labour requirement for pruning were measured twice. At the end of the dry season it costs about 26 hrs./ha. Carrying the 400 kg home takes another 13 hours (16 trips of 30 kg). After drying, 200 kg firewood is left with a value of 1,000 Tsh. This gives a return of 26 Tsh/hr. This is reasonable if the pruning is done at the end of the dry season. The second pruning after 4 weeks took 16 hours. As these have a very high opportunity costs (it is done at prime time for weeding) this is equal to about 1,000 Tsh.. It yields no firewood.

In total the alley-cropping performed fairly well biologically, but economically it is risky and gives no extra returns to the labour invested. As in the present trial the trees were very well established and as the field was well maintained all possible positive effects were obtained, but it must be feared that on farmers field this is not the case.

No dramatic effect on the position of women is expected. It might be slightly positive as they might not be responsible for the pruning while they get the benefit of the little firewood from it.

Figure 21 Pruning at the end of the dry season gives some firewood

Other criteria
The innovation is risky as in a dry season the yields are less than in a normal field. Secondly any delay in pruning the trees at the beginning of the rainy seson has a dramatic bad effect on the yield. If a farmer is away or sick for one week at the crucial period yield reduction will be very big, much bigger than with normal weeds as the Leuceana is well established and very vigorous.

This brings us to a second problem. The innovation is fairly complex. Many management questions still need to be answered. What is the best timing for pruning, which spacing is optimal. Many farmers who visit the plot would like a wider spacing of trees. This might be advisable as it reduces the costs and the risks and possibly it only brings the anticipated results only later.Specially outside Mvumi, where wind erosion is more sever a wider spacing might still have a positive effect by reducing the wind erosion while the water competition is reduced. A last complicated issue is what to do with the crop residues? Burning is risky and taking it of the plot is laborious and contradictionary with the aim of increasing the soil fertility.

The integration aspects are very well of course, as are the marketing, the capital requirements and the institutional sustainability (once adopted by farmers). The labour requirements are obviously negative. Experiences of DOVAP show that the Wagogo have no social or cultural objectives to alley-cropping.

Conclusions
Although alley-cropping performed fairly well in the on-station trial it is economically not attractive and too risky to bring it to the farmers. On the other side are it's intrinsic possibilities big enough to keep on discussing it with farmers to see how it can be modified.

10.4.2.3 Dispersed trees in farmers fields

In order to reduce the work involved in alley-cropping farmers could also leave some natural germinating trees in their fields. Some candidates are of course the Acacia's and f.e. the Chordia garaf which are already left in the fields sometimes. When this issue is discussed with farmers they always answer that it is not possible as it would increase the incedence of birds. Another worry is the competition and the work involved in pruning them.

As in many other issues it must be assumed that the present farmers practice is optimal or at least there is no evidence that it is not. As the problems of birds has decreased a lot in the last decades in the western part of the division and as firewood gets more scarce, slowly farmers might leave more trees in their fields.

10.4.3 Tree planting

It can be estimated that per household several hundreds of trees are needed to secure the need of firewood and construction wood. HADO has been working on this and although they are quite succesfull (particularly in the western part of the division) still many things can be improved, so that more trees will be planted, of more appropriate species and with a higher survival rate.

For this first more research needs to be done into survival rates of different species at differen sites. This must include local species. Some species which are not yet used can be tried as well, f.e. Grevilea can be tried in valleys. Also more fruit species are needed (specially in the eastern part). In tayloring the messages and the seedlings offered more towards specific needs and specific target groups it seems more seedlings can be planted. This can not be called an innovation; what is needed are just some improvements on the existing practice, so it will not be further discussed here.

10.4.4 Improved management of natural vegetation

Introduction
After the destocking the natural vegetation has improved tremendously and now plenty of grasses and scrubs can be seen. In the case of the grasses the zero-grazing is a way of managing these resources in a sustainable and economic attractive way. The scrubs and trees however are untill now just protected. Sometimes this leads to unaccessable thickets (f.e. between Idifu, Ndebwe, Miganga and Handali). These could be managed more actively by HADO and villagers themselves. People could be given a license for making charcoal, cutting firewood or cultivation under the pre-conditions that they save certain species (which produce building materials or which have other attractive characteristics) and certain areas (f.e. leave a strip of natural vegetation every 100 meter).

The same principle could be used to regulate the cutting of natural vegetation on hill slopes. In some areas these slopes are illegally cultivated. The people concerned have no right nor any certainty over the area so they often just clear an area, cultivate it for a few years and leave it. Every now and then some are caught by HADO and given a fine. If they could be allowed to cultivate under certain pre-conditions this might give better results. One pre-condition should be that strips of uncultivated land are left between the fields. In areas outside Mvumi this seems to be the common practise as long as enough land is available (f.e. along the road to Dodoma, near Ntyuka and Mapinduzi). Another pre-condition could be the construction of contourbunds.

Pre-conditions
If well done it can be both ecologically sound and economically attractive. Seeing the risk that it is not well implemented it might also lead to ecological problems. Not doing it possibly also means that the ecological problems are increased elsewhere.

It could bring some income to the charcoal burners, the village and to HADO. It could also improve the position of women as the illegal cutting of firewood on unwanted places is reduced.

Other criteria
The major problem is the risk. How to assure that someone with a license is not cutting outside the area he has been allocated? It is the same problem of controlling the situation which led HADO to destock the whole division instead only the most degraded part of it.

On the other hand one can claim that the strong presence of HADO personel makes it less risky in Mvumi than outside. Another point is that the destocking has already led to an increased degradation elsewhere and Mvumi can not go on in transporting its problems to other areas. Somewhere in the future Mvumi must take its own share of the problems. So the question is not if this should be done but how and when. Strenghtening the participation of people in the management of their natural resources and improving the reliability of the local courts must be considered as high priorities in this respect. The experiences of DLUMP with participation might be of very good use here.

10.5 Conclusions

The next decision matrix gives an overview of how the different innovations were assessed. Not all ideas are included, mostly as not enough data are available to justify any judgement. Others are left out as they are just a description of an on going process or they only adress institutional issues.

Table 24 Decision matrix for the most relevant innovations

innovation	ecology	economics	pos. of women	remarks	recommendation
new varieties	+	+	0	on farm trials	Impl.
sunflower	0	+	+		Impl.
chemical N-fertilizer	+	?	0	may be only source of N	MP.
organic manures	++	--	0	too laborious	NA.
contour-bunds	+	-	0	too laborious	NA.
intensive gardening	0	++?	0	lack of data	Re.
mechanisation	0	-	0	too short rainy season	NA.
stripping/ topping	0	-	0	reduces grain yield	NA.
deep litter stable	+	?	0	lack of data	Re.
biogas	+	?	+	needs institutional support	MP.
alley-crop.	+	-	0	risky	NA.
management of nat. veg.	+	+	+	risky, how to control	Re.

Explanation: Impl.= ready for implementation; NA.= Not Appropriate; MP. = Monitor Prices: innovation is appropriate if its economics are found to be positive; Re. = Research: innovation seems appropriate but more (practical) information is needed to be sure.

Table 24 shows that for many innovations the economics are negative or unknown. As a result only two innovations can be implemented without any reservations: new varieties of millet/sorghum and sunflower production and processing.

Two other innovations have a positive impact on the ecological sustainability but their economics are unclear: N-fertilizer and biogas. In those cases the innovation can considered to be fit as soon as it is clear that it gives a positive economic return. In order to find this out for the N-fertilizer only the prices of CAN and cereals need to be known. For biogas the total costs (in labour and cash) need to be monitored in some households practising it.

Three innovations are thought to be positive but too little information is available on several aspects: intensive gardening, deep litter stables and menagement of the natural vegetation. For the intensive gardening more information needs to be collected from the farmers practising it. As deep litter stables are yet unknown it needs to be tried out first at the demonstration unit of the MRTC. Active management of the natural vegetation needs to be tried on a pilot scale (one village). HADO and DLUMP are the most appropriate organisations to guide this process.

Five innovations are not applicable, all because their economics are poor: organic manures, contourbunds, mechanisation, stripping/topping and alley-cropping. This is not to say that these innovations should be completely ignored; for some it might be possible to further adjust them to the local situation. F.e. in alley-cropping the distance between the rows of trees can be increased, contours might be converted in small ridges, compost can be tried in combination with intensive gardening, stripping/topping can be modified to early harvesting of crop residues etc.

It is remarkable that only two innovations have a positive effect on the position of women; on the other hand non of the innovations has a negative effect on their position. This is a result of the fact that the work of men and women in agriculture is fairly similar, so if an innovation seems appropriate both men and women profit. Seeing the poor productivity in crop production it can hardly be used to improve the position of women. Zero-grazing can do this as it gives high returns to (off-season) labour, so as much as possible improved cows should be given to women. In general it seems that off farm activities offer better opportunities for women: not only traditional activities as beer brewing and salt making but also small businesses and more formal jobs (so better education) will be important.

Next to the above a lot of other things can be done to promote agricultural development in Mvumi:

- further improve the productivity of the zero-grazing, f.e. via a better monitoring system (which is developed at the moment at the MRTC) or via improving the marketing of the milk (by selling it in Dodoma);
- improve the supply of essential and cheap drugs for livestock, f.e. for pigs and chickens;
- improving the existing tree planting programs via more suitable species and more extension on the use and management of trees;
- allow farmers to go back to their former homesteads if they like to do so;
- encourage the use of (hand)carts;
- stimulate off farm activities via small loans, specially for grainbanks;
- training of the VEW's so that they appriciate the existing farmers practices better and learn to work on small steps (like those described in 10.2.2) rather than on big improvements which are bound to fail.

This whole study is based on present prices, but price relations between labour and land and between inputs and farm products are changing all the time. So good ideas of today may turn impossible and impossible ideas of today might become attractive later. So for any project or program the most important thing to do, is to regularly monitor prices of inputs and farm products and to keep in touch with the farmers. Only in the direct contact with farmers the (usually small) improvements can be detected which are economically viable. These contacts as such are valuable as they can contribute to the process of more cooperation between villagers and between villagers and outsiders. Ultimately this can contribute to more trust among the people and to better leadership in the communities, both pre-conditions for sustainable development.

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