Potential for improving rice production in Tabora Region, Tanzania and implications for village planning (ODNRI Bulletin No. 29)

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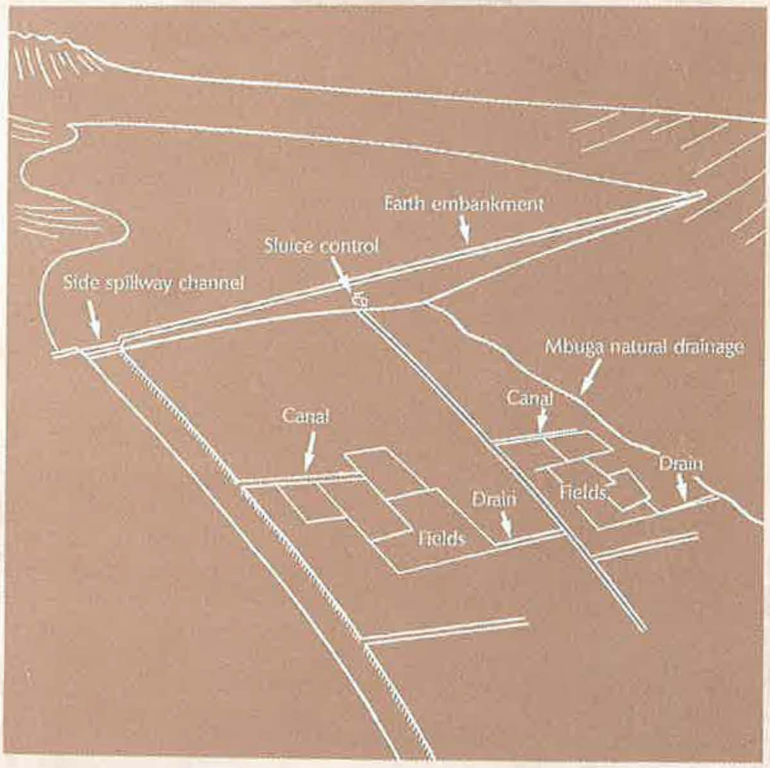

OVERSEAS DEVELOPMENT NATURAL RESOURCES INSTITUTE
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POTENTIAL FOR IMPROVING RICE PRODUCTION IN TABORA REGION, TANZANIA AND IMPLICATIONS FOR VILLAGE PLANNING

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GLOSSARY OF TERMS AND ABBREVIATIONS

ADB	African Development Bank
Braided	Sub-divided into separate channel (as used of a water course)
Bund	As used in this bulletin: a low earth embankment used to aid water control for rice growing
Bunding	The building of a bund, e.g. around the field boundary
Bunded field	Field surrounded by a bund
GOT	Government of Tanzania
HCC	Human carrying capacity (of land)
LRS	Land Resource Study
LUPP	Land Use Planning Project
mbuga	Low-lying land subject to seasonal flooding
ODA	Overseas Development Administration
UNDP	United Nations Development Programme
Usufruct	Traditional system of land tenure whereby land belongs to the community but an individual has the right to use it

Summaries

SUMMARY

This bulletin is based on a two-month consultancy undertaken during March to May 1987. The Overseas Development Administration (ODA) had previously carried out a land resource study of the Tabora Region between 1977 and 1981. ODA later provided technical assistance in village planning, during which the need to incorporate rice production into the village planning models became evident.

The importance of rice as a subsistence and cash crop is growing rapidly both regionally and nationally. The Government of Tanzania places much emphasis on rice production, initially to reduce imports and then to establish an export base. In Tabora Region as a whole, the availability of land (low-lying 'mbuga' land) and water for growing rice is very large in relation to the available labour (population). It is only recently, however, that a small proportion of the region's farmers has begun to grow rice seriously. Only a few farmers are experienced and confident rice growers and few extension facilities are available for this crop.

The potential for, constraints to, increased rice production differ widely among the villages in the region. In villages with a high population density in the northern and north-eastern parts, access to village rice land, and more importantly to water resources, seems to be the main constraint. In those with a lower population density, labour shortage and lack of confidence among the farmers are the main constraints. Increasing transmigration from the highly populated north-eastern quarter of the region to other parts is helping to correct the imbalance in population and should be encouraged.

The region's rainfall is inadequate for growing rainfed rice but supplementary sources of water could be developed to allow flood rice to be grown at acceptable risk levels. The scope for improving the efficiency of water use varies among villages. Improvements would enable a gradual increase in rice production. Farmers would be able to maintain a steady and more reliable rice component within their individual cropping patterns, which is important in the context of village planning.

In villages where water is already being efficiently harnessed and used, further improvements are likely to result only in small increases in the area of rice cultivation and in village rice production. If low-cost technology is used they would nevertheless be worthwhile in increasing the reliability with which rice can be grown.

In other villages relatively few farmers grow rice; it is ironic that many of these are in the wetter southern and western parts of the region. By making available to farmers improved water harnessing technology and demonstrating how flood rice can be grown without incurring large risks of drought-induced crop failure, village rice production, particularly in the wetter parts of the region, could be increased substantially.

Although villages in the region vary with respect to the potential impact of the development of supplementary water resources on rice production, it is considered that much could be achieved by providing technical assistance to facilitate better harnessing and control of supplementary water by farmers. An outline of the proposed assistance is given in Appendix 3.

Formal irrigation schemes with their requirement for large capital investment are considered inappropriate. Instead, a simple, low-cost technology is advocated for procuring supplementary irrigation water. The strategy proposed is based on improving the existing technologies at their margins, calling for no inputs other than local labour, several man-years of technical assistance and a minimal amount of construction materials and tools. Improvements to the existing water harnessing/control systems should be carried out in the farmers' fields on an experimental basis and then this should be followed by extension throughout the region. Training of farmers and local technical officers during the initial stages is a key component of the proposed programme and success will depend almost entirely on the ability, skills and commitment of the trainees.

Shortage of labour is sometimes a greater constraint to increasing rice production than are problems concerned with supplementary water. With good rainfall and ample upland land, villages in the southern and western districts adhere to traditional upland cropping. Cattle-owning migrants arriving here from the north are using their few work oxen to open up

relatively large areas of rice but the extent to which draught animals are used to grow crops in the wetter zone is nevertheless extremely small.

Assistance to develop and train draught animals in large numbers, develop and make available animal-drawn agricultural implements, encourage cattle owners to stock more draught animals and train farmers in their use would help to alleviate agricultural labour constraints. Although the Tanzanian Government and international agencies are keen to introduce agricultural machinery, this is considered inappropriate in relation to the national and regional economic status and lack of back-up facilities.

The extension service needs to be expanded and improved in order to increase the number of rice growers. Extensive uptake of rice growing could be achieved by demonstrations of successful rice growing in village plots using village rice growers. Significant increases in rice yield could be expected if farmers were encouraged to improve on timing of nursery preparation and transplanting, planting densities, planting material and other cultivation practices, and assisted to streamline their agricultural labour resources more efficiently. Some other problems that need resolving in attempting to increase rice production are access difficulties to mbugas, land tenure, agricultural credit, marketing problems, price incentives and fluctuations, vermin damage and health (malaria) problems.

The procedure for land allocation within existing village planning models is unsuitable for rice. However, if the village as a whole (rather than an average household) is considered as the planning unit, rice production can easily be incorporated into a village planning model designed to ensure the viability of the village. Rather than break up existing large rice farms (which are the most productive) to distribute mbuga land to villagers whether they want it or not, it would be better to delay such redistribution until the demand resulting from increased interest by small rice growers warrants this. Under the current land tenure system there are relatively easy mechanisms by which a farmer who is keen to grow rice can obtain mbuga land without causing the village rice production to drop.

A methodology was developed to assess the area of rice that can be grown in a village subject to the likely water availability (see Appendix 2). In developing this methodology, no constraints to rice production other than water availability were considered.

The potential to increase rice production significantly at the village level much depends on the farmer adopting better water harnessing/control and agronomic practices. It is recommended that ODA consider providing technical assistance to develop and disseminate simple, low-cost techniques in the fields of irrigation engineering and rice agronomy to enhance regional rice production.

Labour is a major constraint to increased rice production. Opportunities exist to alleviate labour shortages through enhanced use of work animals. A programme of assistance to develop the use of work animals is also recommended.

RÉSUMÉ

Ce bulletin se base sur une mission de consultation de deux mois entreprise de mars à mai 1987. L'Overseas Development Administration (ODA) avait déjà effectué entre 1977 et 1981 une étude des ressources du sol de la région de Tabora. L'ODA a fourni par la suite de l'assistance technique sur le ruralisme villageois, à l'occasion de laquelle il devint évident qu'il conviendrait d'inscrire la production de riz dans les modèles de planification de village.

L'importance du riz comme culture de subsistance ainsi que de rente s'accroît rapidement à l'échelle régionale et nationale. Le Gouvernement de Tanzanie attache beaucoup d'importance à la production de riz, d'abord pour réduire les importations et ensuite pour établir la base d'exportations. Dans la région de Tabora, prise dans son ensemble, la disponibilité de terre (terre 'mbuga' à relativement basse altitude) et d'eau pour la riziculture est très abondante en comparaison avec la main d'oeuvre (population) disponible. Pourtant, ce n'est que récemment qu'une proportion restreinte des cultivateurs de la région a commencé sérieusement à cultiver du riz. Seuls, quelques cultivateurs sont des riziculteurs expérimentés et confiants en eux-mêmes et il n'y a guère de services de vulgarisation pour cette culture.

Le potentiel d'augmentation de la production rizicole et les contraintes qui s'y opposent diffèrent largement d'un village à l'autre dans cette région. Dans les villages à forte densité démographique du nord et du nord-est, la principale contrainte semble résider dans l'accès à des terres à vocation rizicole et, ce qui importe encore davantage, aux ressources en eau. Dans les districts à plus faible densité démographique, les grandes contraintes sont la pénurie de main d'oeuvre et le manque de confiance de la part des cultivateurs. L'intensification de la transmigration à partir du quart nord-est de la région, qui est très peuplé, vers d'autres parties aide à remédier au déséquilibre démographique et il convient de la favoriser.

La pluviosité de la région ne convient pas à la culture du riz pluvial, mais il serait possible d'exploiter des ressources supplémentaires d'eau pour permettre de cultiver du riz aquatique

sans trop courir de risques. Des améliorations permettraient d'intensifier progressivement la production rizicole. Les cultivateurs pourraient ainsi maintenir dans leurs systèmes individuels d'exploitation un élément riz plus stable et plus fiable, ce qui est essentiel dans le contexte de la planification de villages.

Dans ceux des villages où l'eau est déjà suffisamment bien exploitée et utilisée, de nouvelles améliorations ne pourraient probablement assurer que de légères augmentations de la superficie des rizières et de la production de riz des villages. Néanmoins, le recours à une technologie à coût modéré aurait l'avantage d'accroître la fiabilité de cette culture.

Dans d'autres villages, assez peu de cultivateurs font du riz: ce qui est ironique, c'est qu'un grand nombre d'entre eux sont dans les parties sud et ouest de la région, qui sont les plus humides. Il serait possible d'accroître nettement la production rizicole des villages, et cela surtout dans les parties les plus humides de la région, si l'on fournissait aux cultivateurs de meilleurs moyens d'utiliser l'eau et si on leur démontrait comment cultiver le riz aquatique sans risquer de subir un échec de la récolte en cas de sécheresse.

Bien que les villages de la région varient quant à l'impact potentiel du développement de ressources additionnelles d'eau sur la production rizicole, il est à prévoir que des résultats concrets pourraient être obtenus si une assistance technique était fournie pour faciliter un usage correct des compléments d'eau par les cultivateurs. L'Appendice 3 contient un schéma de l'assistance proposée.

Des systèmes d'irrigation proprement dite ne paraissent pas à conseiller, avec leurs importants investissements de capitaux. Une technologie simple et peu coûteuse est préférable pour fournir une irrigation d'appoint. La stratégie proposée est basée sur l'amélioration de certains aspects des technologies existantes, ce qui n'exigerait aucun intrant nouveau, sauf de la main d'oeuvre locale, quelques années-homme d'assistance technique et une quantité minime de matériaux et d'outils de construction. Des améliorations du système existant d'aménagement et de régulation des ressources hydriques seraient effectuées dans les champs des cultivateurs sur une base expérimentale et ce serait ensuite la vulgarisation dans toute la région. La formation des cultivateurs et des encadreurs techniques pendant les étapes initiales constitue un élément-clé du programme proposé et le succès dépendra presque entièrement de l'aptitude, des dextérités et de l'enthousiasme des personnes à former.

Le manque de main d'oeuvre représente parfois une contrainte plus grave qui freine l'augmentation de la riziculture, que les problèmes relatifs aux appoints d'eau. Avec une bonne pluviosité et l'abondance de terre de colline, les villageois des districts sud et ouest pratiquent la culture pluviale traditionnelle. Les immigrants qui viennent du nord, et qui ont du bétail emploient leur quelques boeufs de trait pour mettre en oeuvre des superficies relativement importantes pour la riziculture, mais ce n'est encore que dans une très faible mesure que la culture attelée sert dans la zone plus humide.

En aidant à mettre au point et à former de grands nombres d'attelages et en fabriquant et mettant à disposition des instruments agricoles pour traction animale, en encourageant les propriétaires de bovins à disposer de plus de bêtes de trait et en apprenant aux cultivateurs comment s'en servir, on réduirait les contraintes de main d'oeuvre agricole. Bien que le gouvernement tanzanien et les organisations internationales souhaitent introduire de la machinerie agricole, ce n'est pas là un projet constructif, compte tenu du bilan économique national et régional et en l'absence de dispositifs d'entretien.

Le service de vulgarisation a besoin d'être élargi et amélioré, afin d'accroître le nombre de riziculteurs. La riziculture pourrait être largement intensifiée grâce à des démonstrations de culture couronnée de succès par des riziculteurs de village, dans des parcelles de village. Le rendement pourrait s'accroître nettement si l'on encourageait les cultivateurs à mieux respecter les dates de préparation des pépinières et des repiquages, des densités des semis, du matériel de plantage et autres façons culturales, et si on les aidait à mobiliser plus efficacement leurs ressources en main d'oeuvre. Quelques autres problèmes doivent être résolus pour augmenter la production: faciliter l'accès aux mbugas, et alléger des contraintes du régime foncier, du crédit agricole, de la commercialisation, de l'attraction et des fluctuations des priz, et des dégâts des rongeurs et des problèmes sanitaires (paludisme).

La procédure d'attribution de terres dans les modèles actuels de planification des villages ne convient pas à la riziculture. Toutefois, si le village tout entier, (plutôt que la famille moyenne) est considéré comme l'unité de planification, la production rizicole pourra facilement s'intégrer dans le modèle de plan villageois conçu pour assurer la viabilité de la communauté. Plutôt que de démembrer de larges exploitations rizicoles (qui sont les plus productives) pour distribuer de la terre mbuga aux villageois, qu'ils en veuillent ou non, il vaut mieux remettre cette redistribution jusqu'à ce qu'elle soit justifiée par une demande évidente de la part des petits riziculteurs. Le régime foncier actuel contient des mécanismes qui permettent assez facilement à un cultivateur désireux de cultiver le riz d'obtenir de la terre mbuga sans provoquer une baisse de la production du village.

Une méthodologie a été formée pour évaluer la superficie à vocation rizicole d'un village, en fonction de la disponibilité d'eau (Cf Appendice 2). Pour élaborer cette méthodologie, la seule contrainte de la production rizicole qui a été considérée était celle des ressources hydriques.

Le potentiel d'augmentation significative de la production rizicole au niveau du village dépend largement de l'adoption par le cultivateur d'un meilleur régime de l'eau et de meilleures façons culturales. La recommandation est que l'ODA envisage de fournir de l'assistance technique pour développer et faire connaître des techniques simples et peu coûteuses dans les domaines des dispositifs d'irrigation et d'agronomie rizicole pour accroître la production régionale de riz.

Le manque de main d'oeuvre est une grande contrainte de la production rizicole. Il est possible d'y remédier en employant davantage la traction animale. Il est aussi recommandé d'adopter un programme d'assistance quant à l'usage de bêtes de trait.

Section 1

Introduction

A Land Resource Study (LRS) of the Tabora Region was carried out by the then Land Resources Development Centre of the Overseas Development Administration (ODA) during 1977-1981. The study team recognized the importance of rice as a food commodity and its increased production as a means of sustaining the human carrying capacity in the region. It considered lack of water to be a major constraint for increasing rice production and recommended a programme of investigations into better water control systems and associated agronomic practices.

Following the LRS, ODA provided technical assistance to the Government of Tanzania (GOT) in village planning in the Tabora Region. Originally it was thought that the villages could be planned over a reasonable time horizon relying mostly on upland cropping as the agricultural production base. However, it was found that, in northern districts in particular, the upland agricultural productivity per unit area and the total upland crop production per capita were too small even to sustain the current population demands. The need to incorporate rice production in the village planning models soon became evident. In southern districts although pressure on land was not too great, the rapidly expanding area under rice indicated its growing importance to villagers and immigrants.

In attempting to incorporate rice production in to village planning, one need was to assess the village's potential to grow rice. Because of the region's inadequate rainfall this required an assessment of water resources. ODA agreed to provide a consultant for a period of two months with the following terms of reference:

(a) to familiarise himself with all aspects of rice growing in the region;

(b) to assess the extent to which the available water resources constrain rice production;

(c) to develop a set of guidelines to assist village planners in their estimation of the villagers' rice growing potential, subject to water availability;

(d) to identify low-cost water resource development techniques to increase the reliability of available water for rice production.

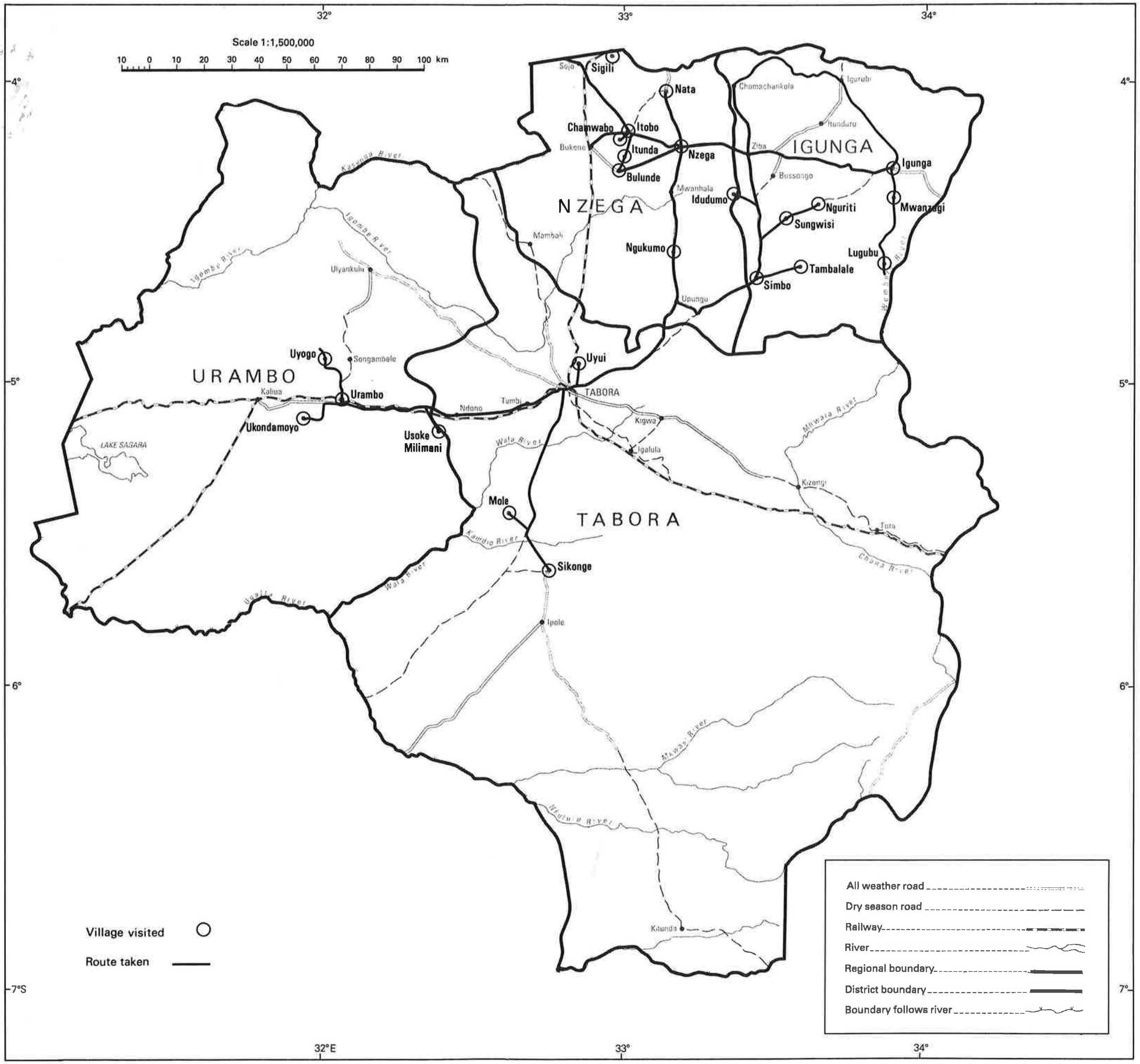
The consultancy visit took place during March to May 1987. Seventeen villages, covering all four districts in the region, were visited. At each village, both rice growing and uncultivated, low-lying 'mbuga' land and their environs were inspected. The routes traversed and the villages visited are shown in Map 1. Farmers, village leaders or elders and village government officials were interviewed to determine: the constraints preventing increases in rice production as perceived by the villagers; to what extent the farmers viewed water shortage as a problem; and the local rice cultivation practices which directly influence crop water requirements. Some time was spent in the Headquarters, and in Regional and District offices of Land Use Planning, Agriculture, Water (Maji) and Irrigation to gather information on hydrological data, policy matters and other activities relevant to the investigation.

In both the national and regional context, the importance of rice as a food commodity is growing fast. The government is keen to increase production to meet the rapidly increasing local demand and with the hope of being able to export to neighbouring countries in the near future. At present, however, Tanzania is an importer of rice.

Although rainfall in the Tabora Region is insufficient for rainfed rice, it is adequate for flood-rice if supplemented with water from other sources. These sources could be developed using low-cost techniques appropriate to the level at which rice is currently being cultivated by indigenous farmers. Water shortage is therefore not necessarily a more serious constraint to increased rice production than other factors such as shortage of labour, land and water rights and lack of agronomic support.

Regional rice production could be increased substantially in the medium to long term if measures were taken simultaneously to alleviate water, labour and agronomic constraints. A strategy based on simple, low-cost, but appropriate technology is advocated and appropriate technical assistance is recommended.

Allocation of mbuga rice plots among individual families according to currently advocated village planning models could create problems. Rice production is, however, a significant component of the village agricultural production base and should not be ignored. In the short to medium term, it should be included only in planning models designed to plan the village as a whole rather than to plan for the viability of individual families in the village.



Map 1
Itinerary of a visit to Tabora Region

Section 2

Rice cultivation and irrigation in Tanzania

Although long grown in East Africa, rice has been produced in Tanzania as a recognized crop only since the second quarter of this century. Today, however, next to Madagascar, Tanzania is by far the largest rice producer in East Africa.

Rice is grown in all 20 administrative regions of the country but only six have major rice producing areas, for example Bukene and Puge Plains in the Tabora Region. Most of the rice in Tanzania is grown by peasants in the river valleys and low-lying mbuga land usually relying on other sources of water to supplement the rainfall. Only about 10,000 ha of rice land receive conventional irrigation and they are managed by the government as large-scale state farms (Chinganga, 1984). In areas of the country where the rainfall is favourable, rainfed (pluvial) rice is also grown.

During the last two decades, the per capita rice consumption in Tanzania has doubled, indicating the growing importance of rice as a food commodity as consumer tastes change. It is now estimated that over 50% of the population are rice eaters (Chinganga, 1984).

More than 300,000 ha may be currently cultivated under paddy, about double that during the early 1970s (Table 1). Over the same period, production seems to have increased only by about 50% to about 300,000 t, implying a decrease in national average yield per ha.

In recent years, the potential demand for rice has reached about 400,000 t/year, and the trend is upwards. The government is keen to achieve production levels in excess of 450,000 t to allow a small surplus for export to neighbouring countries, having reserved a sufficient buffer stock against unfavourable years. Current production is well short of this and the country is importing about 60,000-100,000 t of rice per year, thus losing extremely scarce foreign exchange when ample opportunities – particularly land and water resources – exist to reverse the situation.

As citied by Mrema (1984), about 85% of the country receives more than 500 mm of annual rainfall and over 50% receives 750 mm. Studies during the last two decades have identified 850,000 ha of land as having immediate irrigation potential and the long-term potential is estimated to be 4 million ha. Of the total land area of some 90 million ha, only 6% is under cultivation of which only 3% (about 175,000 ha) is irrigated. Nearly 95% of the cultivated area is under small-holder peasant agriculture and 80% of irrigated land is also under traditional (indigenous) irrigation. Conventional modern small- and large-scale irrigation in both the private and public sector accounts for <30,000 ha. Large-scale irrigation enterprises, which vary from 400 to 3000 ha, account for >25,000 ha and are centrally managed either by private or parastatal organizations. They are fairly efficiently managed; high value crops are grown but their initial investment costs are high, up to about US$10,000 per ha.

Considering traditional small-holder irrigation to be inefficient, colonial and subsequent governments have since the mid-1900s built conventional irrigation schemes. By about 1965 some 20 such schemes, each designed to irrigate between 50 and 300 ha, were complete. Although costly to build and run,

Table1

Rice harvest, production and imports

Year	Harvested area† ('000 ha)	Production‡ ('000 tonnes)	Imports§ ('000 tonnes)
1969	144	172	*
1970	151	192	*
1971	151	202	*
1972	*	178	*
1973	*	193	*
1974	137	141	71
1975	137	157 (294)	64 (21)
1976	137	180 (354)	9 (5)
1977	150	203 (375)	45 (49)
1978	250	260 (350)	55 (41)
1979	200	250 (300)	7 (55)
1980	275	291	80 (65)
1981	275	280	45
1982	280	267	30

Sources: As cited by Chinganga (1984)
Figures in ( ) as cited by Ministry of Agriculture, Zimbabwe (1982)

Notes:
* Data not available
† Areas of rice harvested are calculated from the returns submitted by extension officers stationed throughout the country. The figures could be subject to significant error because of: (a) the sparse density at which extension officers are stationed; (b) the widely scattered nature of most parts of the area cultivated; (c) failure of the extension workers to visit many of the rice growing areas due to access difficulties and lack of transport, motivation and supervision; (d) the method of estimating area which is done entirely by visual observation.
‡ Until about the mid-1970s all rice growers were obliged to sell their surplus produce to the government and the government estimated production figures were reasonably accurate. After market liberalization, the importance of rice as a cash crop grew and it did not all pass through government stores. The production figures quoted since the mid-1970s are therefore no more than calculated guesses. This may explain the significant differences in production figures from different sources.
§ No explanation could be found for the differences in import figures and it is not certain whether rice arriving as food aid is counted as import.

most have been unsuccessful and irrigation has reverted after a few years to the traditional system.

Despite the availability of immense land and water resources to develop irrigated agriculture, experience so far has created a cautious approach to future investments. Recently the government, with the assistance of external development agencies, has attempted to salvage some of these unsuccessful projects and has also invested in a few new ones. It is difficult to see, however, to what extent lessons have been learnt from the past and the new projects are designed accordingly. Details of three such projects as cited by Mrema (1984) are summarized in Table 2.

Table 2

Comparative summary of three typical small-holder conventional irrigation schemes

Scheme (Region)	Mlali (Morogoro)	Mombo (Tanga)	Mto wa Mbu (Arusha)
Planned command area (ha)	65	160	200
1955 per ha development cost (US$)	320	225	410
Average holding size (ha)	1.2	1.5	1.8
Expected average paddy yield (t/ha)	1.3	1.2	1.0
Year of rehabilitation	1983–84	1979–80	1980–81
Adjusted per ha rehabilitation cost (US$)	3200	2120	4910
Donor/sponsor	Government of Tanzania	West Germany	International Labour Organization

Source: As cited by Mrema (1984)

In relation to agronomy, modest programmes have been planned in collaboration with the International Rice Research Institute for research into high-yielding varieties and their associated high-cost inputs.

Little emphasis seems to have been placed on improving either through research or extension, the indigenous irrigation as practised by peasant farmers; this accounts for more than 80% of national irrigation. There is little current investment and work by the formal authorities.

Among its attempts to increase rice production, the government is entering into joint ventures with foreign commercial agencies to allow them to grow rice in Tanzania. The government is also keen on bilateral and multilateral aid agencies investing in rice schemes, preferably planned, it seems, along conventional lines with 'high-tech' inputs in spite of their high risk and invariably high capital implications.

Although the government seems to have no major formal plans to improve or invest in traditional rice cultivation using low-cost but appropriate technology, it does not follow that it lacks interest in such development propositions. Ideologically, the government is extremely keen on the secondary benefits of such development programmes. The most important of these are the generation and distribution of income through the creation of rural employment – benefits which power the process of rural development.

Section 3

Rice growing in Tabora Region

AREA UNDER RICE CULTIVATION

Rice is grown in all four districts of Tabora Region (see Map 1), Nzega District being by far the dominant one. Compared with the area cultivated under upland crops, maize in particular, the area of rice is small. The land use as it was in the early 1980s is shown in Table 3. Of the land allocated for the villages only about 2% was taken up for rice cultivation, and of the total land cultivated, rice accounted for <10%. It should be noted that rice is not grown every year in all the bunded fields and the actual annual area of rice cultivation over time must have been significantly less than Table 3 suggests.

Table 3

Areas of land use category (km²)

Land use category	Distribution among districts				Tabora Region
	Tabora	Urambo	Nzega	Igunga	
Upland cultivated/fallow	1590	860	2365	3210	8025
Upland bush and grassland	315	0	795	1660	2770
Thicket and woodland	10,750	6010	1285	515	18,560
Total upland allocated to villages	12,655	6870	4445	5385	29,355
Bunded rice fields	220	80	610	160	1070
Mbuga grassland and swamps	3865	3350	900	1130	9245
Total mbuga allocated to villages	4085	3430	1510	1290	10,315
Total land allocated to villages	16,740	10,300	5955	6675	39,670
Forest and game reserves	21,880	10,400	1275	275	33,830
Total	38,620	20,700	7230	6950	73,500

Source: Mitchell (1984)

About a third of Tabora Region comprises low-lying, seasonally flooded mbuga land, much of which is potentially suitable for rice cultivation. This amounts to some 23,000 km² but only about 4% of this is in the rice cultivation cycle, i.e. bunded land, under cultivation or short-term fallow (Acres, 1980). In the region as a whole, land availability is therefore not a constraint to increased rice production. In Nzega District, however, the prospect for extending rice cultivation is somewhat limited.

Since very little rice is cultivated in unbunded fields, the area of bunded fields shown in Table 3 indicates fairly well the total area under rice cultivation at least once. For a variety of reasons, including uneven rainfall, the proportion of bunded fields actually planted with rice varies considerably from year to year. Only about two thirds of the bunded fields were planted in 1986-87, although it was abnormally wet.

Since the early 1980s rice production in the region has been growing steadily, but the amount of new land bunded for cultivation has not necessarily gone up at the same rate. The regional average paddy purchases between

1966 and 1975 were about 13,000 t per annum, ranging from 1000 t to 26,000 t (Mitchell, 1984). The regional average rice yield is thought to be about 1 t/ha implying that the average area then cultivated for surplus was about 13,000 ha. From the present estimate, of 300,000 ha for the whole country (see Table 1), and bearing in mind that Tabora Region is not one of the largest of the six major rice producing regions of the country, the region's current average annual area of the rice cultivation may be estimated at about 50,000 ha.

THE SPREAD OF RICE GROWING IN THE REGION

Nzega District borders the southern parts of Shinyanga District in the Shinyanga Region, a major rice producing area in the country. In both districts, a large proportion of the population belongs to the cattle-owning Wasukuma Tribe. They are known to be adventurous farmers and have incorporated rice cultivation into their traditional farming systems.

As shown in Table 4 the population and population densities of Nzega District are the highest, and the areas available for upland cropping are the smallest, among the districts in Tabora Region. Upland soils are exhausted and the rainfall is marginal for growing the traditionally preferred maize. Farmers in Nzega District have therefore looked beyond the horizons of their traditional upland-based argriculture; most have encroached on the low-lying mbuga land to grow rice in parallel with their traditional activities. They are serious rice cultivators, leaving only a small proportion of bunded fields uncultivated in a given year compared with other districts. The area of rice in Nzega far exceeds that in other districts in the region.

Table 4

Population and population densities in the districts of Tabora Region, 1978

		Population density (no. of persons/km^2) based on	
District	Population	Total district area	Area allocated to villages
Tabora	187,063*	4.8	11.2
Urambo	105,117	5.2	14.5
Nzega	225,027	31.1	37.8
Igunga	189,486	27.3	28.4
Tabora Region	818,049†	11.1	22.2

Source: Mitchell (1984)

Notes: * Excludes town population
† Includes Tabora Town and Ulyankulu refugees

To some extent the conditions in Igunga District resemble those in Nzega District but the rainfall is even more unfavourable. Little rice is produced and food crop production in general is small, farmers concentrating their efforts on growing more drought-tolerant crops such as cotton and sunflower. A significant number of farmers, particularly those of the Wasukuma Tribe, are migrating from Igunga District to relatively wetter southern and western parts of the region. There, these farmers, who invariably arrive with their animals, are opening up extensive areas of mbuga land to grow rice. As a result, the rice production in Urambo District in particular is rapidly expanding.

Tabora District has a long history of growing rice, albeit on a very small scale, the traditional rice growers belonging to the Nyamwezi Tribe. They use few work animals and their rice holdings seldom exceed a quarter of a hectare. Traditionally rice was grown for subsistence, but now the farmers are keen to produce more than their subsistence needs. This is in response to the growing demand from Tabora Town and the general change in consumer tastes in favour of rice; the farmers wish to benefit from the growing cash economy but their ambitions are greatly hampered by the shortage of labour and work animals.

CROP PREFERENCE

Traditionally farmers grew upland crops for subsistence and the preferred cereal crop was maize. Conditions (access to land, population growth and general socio-political and economic scenarios) have changed and farmers now grow crops in excess of their subsistence needs in anticipation of cash income. Rice is becoming an important cash crop particularly because it does not compete for relatively scarce upland land where most of the subsistence crops are grown.

Farmers nevertheless give priority to cultivation of upland crops, maize in particular, in order to ensure that their preferred subsistence needs are satisfied first. When ample upland is available maize is grown beyond the subsistence needs. Other important upland cash crops are tobacco, sunflower and cotton. Root crops such as cassava and sweet potatoes, legumes such as beans, bambara nuts and groundnuts, and to a limited extent, sorghum are also grown, but largely for subsistence needs.

Maize competes with rice for resources because both require scarce labour at the beginning of the cropping season. With upland crops, maize has to compete for land as well. Shorter fallow periods in uplands, necessitated by population changes, have led, particularly in the northern districts, to a rapid deterioration of soil fertility. Rice land (mbuga), on the other hand, is relatively freely available so when upland land is limited rice has the advantage over maize and other upland crops.

Over recent years consumer preference in Tanzania, particularly in urban centres, has been changing in favour of rice. Rice is also becoming more acceptable as a staple food in the Tabora Region. These factors and the decline in per capita maize production due to the scarcity of fertile land, are leading to a steady increase in rice cultivation in the region.

The labour intensive farming practised in the region requires hardly any capital. The opportunity cost of obtaining land is small and the financial cost, at least in theory, is zero. Under such circumstances, the returns to labour are of paramount importance for choice of crop. In cash terms (Tsh/hour), rice has one of the highest returns on labour (Mitchell, 1984). In terms of the arduousness of the work involved, however, rice is considered by the farmers as a difficult crop to grow. This is because rice lands (mbugas) are usually some distance away from the homesteads; it is difficult to reach individual plots in wet mbugas; and most of the in-field activities have to be carried out in standing water.

Most of the farmers grow crops exclusively with family labour and for them returns to labour measured in terms of Tsh/hour have little relevance. They take account of how hard, as well as how long, they and their families have to work. Growing rice as a cash crop has to compete with other potential cash-earning ventures such as livestock keeping, honey collection, charcoal production and employment in cottage industries. The return to labour from growing rice appears small, particularly to the majority of farmers who lack work animals.

EFFECT OF TRIBAL TRADITION AND DISTRICT/ VILLAGE INFLUENCE ON RICE GROWING

The degree of interest and skill in rice growing varies substantially among the various tribes and districts in the region, being, as stated, greatest in Nzega District and among the Wasukuma tribe. The Nyamwezi tribe is second to the Wasukuma in rice growing, but the average area grown per farmer is much smaller; other tribes attach less importance to rice growing. Tribal composition in the villages, and districts varies considerably and this affects the amount of rice grown. Within a given district the rice production can vary substantially from one village to the next for other reasons as well. For example, while virtually all the farmers in the village Simbo, located on the border of Igunga and Tabora Districts, grow rice extensively, no more than 10% of the farmers in three satellite villages, Sungwizi, Nguruti and Tambalale, grow rice, the area involved being tiny in comparison with that of Simbo. The variability among the villages in Nzega District seems to be less pronounced.

FARMER EXPERIENCE IN, AND ATTITUDES TOWARDS, RICE GROWING

Traditionally rice has been cultivated in Tabora Region only on a very small scale and perhaps on an opportunistic basis; serious cultivation dates back no more than a couple of decades. Rice is cultivated in low-lying mbuga land by practices and under hydrologic regimes very different from those used for traditional upland rainfed crops. No formal attempts are being made to advise the farmers on how to grow flood rice and regularize cultivation practices. The practices improvised vary among farmers and districts. No attempt has been made to determine the best practices and the few extension officers stationed in the districts can give little advice.

The prevailing diversity in rice cultivation practices and soil and hydrologic conditions in the mbugas discourages the potential new rice farmer and leaves him at a loss in selecting the particular set of practices most appropriate to the soil and water regimes of his fields. Adding to the confusion are the attempts, albeit limited, by some government institutions to advocate the use of tractors, high-yielding seed varieties and associated costly inputs, such as artificial fertilizers and high-cost irrigation water, which are totally alien to most of the farmers. These factors create a major psychological barrier to rice growing for all except the more innovative and adventurous farmers and those who have little option but to grow rice, i.e. those who do not have sufficient upland land. Development and selection of basic mbuga rice cultivation practices and associated demonstration and extension work have much to offer in the effort to increase the number of rice growers and, thereby, rice production in the region.

RAINFALL IMPLICATIONS IN GROWING RICE

The mean annual rainfall in Tabora Region ranges from over 1000 mm in southern and western parts to about 700 mm towards the north and north-east. The rainy season lasts about six months, from about mid-November through to early May. The long-term average monthly rainfall is fairly uniformly distributed with a slight peak in December followed by a slight lull in January. There is some year-to-year variation in the monthly distribution pattern.

With supplementary water sources the total amount and monthly distribution of rainfall are generally adequate for growing flood rice in bunded fields. The supplementary sources available in the region are surface runoff, seepage or interflow and shallow ground water, all of which are, in turn, dependent on rainfall. The efficiency with which supplementary water is secured for the bunded fields varies substantially from district to district, from farmer to farmer and from plot to plot.

The rice varieties grown in the region are mostly of long duration (six months). If rice is planted to reap the full benefits of the favourably distributed six month rainy season, and in bunded fields with standing water from direct precipitation and other sources, it should not normally experience water stress. Among the more experienced and serious rice cultivators, especially those in Nzega District, total crop failure due to water shortage seems to occur less than once in 10 years. They are convinced, nevertheless, that rainfall is largely responsible for the significant variations in their annual rice yields. Among the less serious and more opportunistic growers, who are mostly in the wetter southern and western parts of the region, crop failure appears to be more common. In most years, lack of rain cannot therefore be singled out as the reason for crop failure due to water shortage. Common reasons for such failure are delay in planting rice and failure by the farmer to: locate the fields appropriately for receiving supplementary water; harness supplementary water; and store and control in-field water.

Low rainfall spread over a long rainy season, as in the northern districts, does not in general favour the growing of rainfed crops with relatively high water consumption and short duration, e.g. maize; this has a 3-4 month duration compared with 6 months or more for sorghum or cotton. Furthermore, in spite of the uniform distribution of monthly rainfall, the results of the rainfall pentad analysis reported by Mitchell (1984) tend to suggest that except perhaps in southern and western parts of the region, rainfall is unreliable for growing traditional upland crops under rainfed conditions*. Information from the limited pentad analysis carried out suggests that from the point of view of both quantity and reliability of rainfall the eight-week period from mid-November to mid-January is the best for planting crops. The 10-week period to follow is a critical one for upland crops. Flowering of maize and beans, for example, takes place then and yields would be very susceptible to any water-stress at this stage. Unfortunately, drought spells lasting up to about four weeks can occur at this time.

At the onset of the rains farmers concentrate on planting the preferred crop, maize, and rice planting is generally delayed. The larger the upland area cultivated, the smaller the area of rice grown and the longer the delay in preparing the rice nurseries. The more experienced rice farmers, realizing the importance of early planting, do attempt to spend a few days on their rice nurseries during the early rains. The majority, however, appear to operate in response to rainfall conditions. The most common reply from the farmers interviewed was: 'with the onset of rains, the first land to be prepared is upland for maize growing. If, however, this is hard to cultivate, say because the first few rains were not heavy enough, we immediately start preparing rice nurseries as the mbuga soils are more easily softened'.

Conversely, early storms can prolong the period devoted to maize planting and increase the area cultivated, thus delaying rice planting by up to two months. In the wet year of 1986-87, nursery preparation continued until early March in some parts of the wetter zones. In such years, unless the rainy season extends well beyond April, the crop is bound to suffer water stress at the crucial inflorescence stage and yields may be very poor.

CULTIVATION PRACTICES

The timing of planting and transplanting of rice is of major importance in relation to the availability and usage of water for rice production and the resulting consequences for crop yields. Some of the practices adopted in Tabora Region are far from optimum. Relevant aspects of the practices themselves and the constraints to modifying them are discussed below.

Most farmers grow transplant rice which is capable of yielding about 20% more than broadcast rice (Patel and Charugamba, 1981). Another major advantage of transplanted rice is that at the onset of rain, only up to 10% of the final area to be planted has to be prepared as nurseries, thus demanding only a limited labour requirement during this crucial period of labour bottlenecks. The cultivation of the remaining 90% of the rice land starts only when labour becomes available after most of the upland area is planted.

Inundation caused by heavy early rains often delays planting in the lower-lying parts of the mbugas. At the same time such rains favour early planting

*Detailed rainfall data were published by Brokonsult (1980). A thorough examination and analysis of these data was outside the scope of this consultancy.

on the upper parts, i.e. the seepage zone. There is evidence that some rice growers respond by shifting their cultivation from one zone of the mbuga to another at the beginning of the crop season. Land tenure, however, can prevent this.

Preparation of nurseries can be delayed as late as February by inundation or too scanty early rains. Under such circumstances, the relatively shorter duration variety, supa, is grown in anticipation of late rains.

Except for those few who grow large areas (say in excess of 10 ha), farmers who cultivate with oxen spend only a few days in preparing their nurseries. Those who cultivate by hand would also spend only a few days in nursery preparation as the final area cultivated would be up to a hectare. Because of the short preparation time and of the harmful effects of late planting, rice growers must be encouraged to prepare nurseries early in the rainy season even if it means some interruption to their upland cultivation.

The preparation of rice plots, as distinct from nurseries, does not usually start until four to six weeks after the beginning of the rainy season when almost all the cultivable upland is planted. Its timing depends on availability of labour and, perhaps to a lesser extent, of water. By then, December/January, the rainy season is at its peak and the amount of moisture in the soil is usually adequate to undertake wet cultivation.

To plough 0.4 ha (an acre) of mbuga land, a team of four oxen and two adults (usually men) with one plough will take about two days; hand ploughing would require up to about 15 man-days (in practice often 'woman-days'). Land levelling often follows ploughing by oxen and the time and resources necessary could equal that for ploughing.

Transplanting follows almost immediately after field preparation. This is a labour intensive activity demanding more than 25 man-days/ha. Particularly among hand cultivators, the sequential nature of preparation and transplanting requires them to work only on small areas at a time, often on a plot by plot basis. A typical family of three or four adults will take 10 weeks or more (allowing for rest days, rainy days and time spend on household and other agricultural activities etc.) to hand cultivate and transplant one hectare of rice. The time lag between the first and the last transplant could be as long as two months, thus bringing the last transplanting well into February. In February and March there are usually dry spells, sometimes lasting as long as four weeks, when neither transplanting nor preparation of wet land can be undertaken. At about this time the maize harvest increases the demand for labour even further. This means that some rice plants have to remain in the nurseries for up to about four months, two thirds of the crop duration. This is of course, detrimental to obtaining good yields although, since most of the rice varieties being used are slow maturing, the delay in transplanting is less harmful than it would otherwise be. Transplanting delays, inherent in the current agricultural calendar, preclude the potential use of high-yielding varieties.

While the above analysis points to labour constraints as the cause of delay in transplanting, others, for example Mansfield (1982) and Moonen (1986), tend to suggest that farmers deliberately extend the period of transplanting to reduce the overall risk of crop failure due to droughts. Given the rainfall dependent water regime under which flood rice is cultivated (see section on Water Resources), the difference in risk between rice in the nursery and in the rice fields is non-existent or marginal, unless rice is grown in unbunded fields with no provision for conserving water. Farmers have much more to lose than gain by deliberately delaying transplanting.

When the ploughing of rice fields begins (in December or January) most will normally have standing water. The results of a survey carried out to determine farmers' views on when to transplant, and how wet the fields should be before they transplant, vary widely from one to seven days after ploughing, and from just wet to 15 inches of standing water (Mansfield, 1982). From this it is inferred that most farmers transplant in standing water within a day or two following land preparation. Some though, particularly those who plant in lands located towards the bottom of the seepage zone, may occasionally have to wait until the upper lying fields are fully inundated before their plots receive water passing through the upper fields. This is particularly so if the amount of water issued by the source (seepage or gulley) is relatively small in comparison with the command area. These long delays between ploughing and transplanting could therefore be due to circumstance rather than choice.

In view of the variability in provision of water (as described above) and in plot size, and the short duration of the consultancy visit, it is impossible to propose a model which will analyse and explain adequately the prevailing agricultural practices. It appears, however, that planting and transplanting delays, which are injurious to the crop, are largely caused by shortage of labour rather than water.

The rice varieties used have been adapted locally over the course of time and are late maturing and drought resistant. Of the two principal varieties, Faya and Supa, the latter is of relatively shorter duration. Farmers often mix the varieties to benefit from their varied characteristics, notably crop duration; this spreads the risk of crop failure, particularly that due to drought. The use of high-yielding varieties is almost entirely restricted to a few extremely small projects run by state and district administrations. Although the results so far have been disappointing, the government seems keen to encourage the use of improved varieties, especially IR8.

Except where good water control can be guaranteed, either by adequate irrigation or by planting rice in favourably located parts of the mbugas, blanket encouragement to use improved varieties will be counter productive. The suitability of these varieties for local environmental and socio-economic conditions has not yet been rigorously tested. There is therefore no clear extension message to give to the farmers. Furthermore, except for experience gained through cultivating their own rice fields, the few extension officers stationed in the region have little experience or training in rice agronomy.

Wet cultivation and flood rice culture as practised in the region inhibit excessive weed growth and weeds do not appear to cause serious problems for rice growing. Better land levelling in some fields and more regular weeding in general would nevertheless pay dividends.

The few fertilizer trials carried out in the region indicate only low yield responses by traditional varieties: up to 25% and 10% yield increases in response to separate applications of 30 kg of N/ha and 20 kg of P_2O_5/ha respectively (Patel and Charugamba, 1981). For many rice growers, commercial fertilizers are expensive in relation to other cash inputs and the potential cash benefits derivable from resulting yield increases. In the absence of agricultural credit, only the few who cultivate large areas or are relatively rich can afford to apply commercial fertilizers if they want to—the fertilizers are mostly applied only to improved varieties. On the other hand, invariably those who have farmyard manure use it.

The piecemeal planting and transplanting of rice over a long period and the use of mixed varieties often result in uneven maturing of the crop. Harvesting therefore takes place over a long period from early May till August. This allows harvesting to be undertaken by one or two members of the family without experiencing serious labour shortages. However, uneven maturing must affect overall crop yields adversely and also leads to severe vermin damage, thus exacerbating a problem already inherent in the system. Rice fields are generally located far away from the village hamlets and the farmers find it difficult to prevent such losses, particularly those due to birds.

Rice yields in the region vary from a few hundred kilogrammes to about 4t/ha, a variability commonly attributed to differences in water availability and, perhaps to a lesser extent, in soils. As noted, however, the rice growing and skills among farmers in the region vary enormously, and this must also be reflected in the crop yields. Moreover, as also discussed, crop water shortage need not necessarily result from rainfall that is inadequate in amount or timeliness; more often it is due to factors such as late planting or transplanting, inappropriate siting of rice plots and poor water control.

MARKETING OF RICE

Until about the latter half of 1970s farmers were obliged to sell their surplus agricultural produce to the parastatal co-operatives. The market has now been freed to some extent although the government purchasing system still functions. Based on statistics provided by the parastatal organizations, Mitchell (1984) reported that between the mid-1960s and mid-1970s the annual regional paddy purchases averaged about 13,000 t. Since then the officially quoted paddy sales show a remarkable decline in spite of the rapid increase in rice production in the region thus indicating the growth in private trading.

Private buyers visit the more accessible villages and the price at which paddy changes hands varies from about Tsh 600 to Tsh 1200 per bag (approximately 90 kg) depending on the time of the year. Given the wide price differences between seasons, those who can afford to hoard rice do so, but it is the traders whom make the largest profits.

Some of the farmers who live close to main roads use public transport to take their cash crops to the nearby centres or towns. However, the additional sale price they obtain, compared with farm-gate sales, is often exceeded by their expenses in making these journeys.

Government vehicles belonging to the parastatal co-operative occasionally arrive at villages with poor access to purchase surplus agricultural crops but payments are not timely, farmers often having to wait up to a year or more before receiving full settlements. For many farmers, particularly in these villages, marketing of cash crops is a problem and this could be a significant factor discouraging them from growing such crops.

LABOUR CONSTRAINTS

Throughout the region, except perhaps in a few villages, labour shortage is a constraint to increasing agricultural production. The large extent of land remaining uncultivated, particularly in the southern and western districts, highlights this. Upland crops and rice compete for the limited available labour. Labour additional to that needed for growing maize, the preferred crop, and other upland crops is sufficient to cultivate only a small proportion of the extensive mbuga land in the region.

For any farmer, securing a piece of mbuga land for cultivation is relatively easy. As a result, the region has only a small 'landless labour class' as a source of hired labour. Nevertheless, such labour is available in some villages where a 'poverty trap' exists. In the absence of agricultural credit facilities or individual savings (e.g. cash, food and livestock), some, particularly among those in villages where per capita upland agricultural productivity is low, remain trapped in a poverty cycle. Poverty prevents them from cultivating their own land because they are unable either to buy seeds and other inputs in time and/or to survive without any income while waiting for the harvest. These people offer their labour for wages, often to those from other villages. For example, Simbo Village, which grows rice extensively, attracts such labour from the poor neighbouring villages. Although only a few people depend entirely on agricultural wages for their income, spare labour is nevertheless available, outside the periods of peak demand, which are crop specific. If maize instead of cotton or tobacco is the dominant crop in the village cropping pattern, labour to grow rice is unlikely to be available. Where rice cultivation is combined with maize growing, off-peak labour enables little expansion in the area cultivated, but is invaluable in such operations as transplanting and weeding already planted rice crops.

AVAILABILITY AND USE OF WORK ANIMALS

Work animals are present in small numbers in cattle herds and to some extent, their use in crop growing compensates for the labour shortage. In northern districts their use is widespread particularly for rice and consequently the land (both upland and mbuga) cultivated per capita is high. Where rice is predominantly cultivated by hand, the maximum cultivable area per family averages about 0.4 ha. With widespread use of oxen it is two or three times higher.

Only the Wasukuma Tribe combines ownership of large numbers of cattle with extensive crop production. Most of the work animals in the region belong to the people of this tribe although their herds do not all contain work animals. Rice growers of the Nyamwezi Tribe have small holdings and seldom use oxen. Both these tribes are well represented in rice growing villages in Nzega District but, within the village, they are often segregated. Many Wasukuma people prefer to live near the village fringes close to mbugas to allow ample opportunities for their cattle to graze. In the southern districts the farmers from Nyamwezi tribe dominate rice growing but with the arrival of Wasukuma farmers from the north the practice of oxen cultivation is growing. In general, therefore, there appears to be a pattern among the Tabora Region farmers regarding the use of work animals and the part of the village occupied.

A survey of 10 randomly selected farmers from each of six selected villages in Nzega District, revealed that over 80% used oxen for rice cultivation (Mansfield, 1982). Because of the non-homogeneous nature of the population from which this sample was taken and the restricted nature of the survey, it is difficult to draw firm conclusions. It can perhaps be said, however, that more than half of the rice farmers in the northern districts use oxen. In the south, perhaps about 10% do so.

Estimates of district cattle populations made by Ecosystems Ltd in 1978 ranged from 115,000 in Urambo District to 500,000 in Igunga District (Mitchell, 1984). Many families belonging to various tribes own cattle in herds of widely varied sizes but only very few have work animals. Many cattle owners concentrate their efforts on milk and calf production and do not appreciate the value of work animals. Few who own them cultivate large areas of both upland and rice crops and appear to be wealthy. One farmer interviewed in Simbo Village revealed that he and his family of six adults cultivated annually 15 ha of rice in addition to 7 ha of upland with his own and hired work oxen and labour hired from the nearby villages. He said that there were two other farmers among the 500 families in the village who cultivated similar areas.

The relatively few families that own work animals do not usually have any to spare for renting. The available supply is far short of the potential demand and the cost of hiring oxen, which is usually based on area cultivated, varies from Tsh 1700 to about Tsh 2800 per ha. Even at this high price many livestock owners are reluctant to supply work animals as they believe it is not good for the health of the animals. Except among those farmers who are confident of achieving crop yields in excess of say 2.5 t/ha, the practice of hiring work animals is extremely limited. For the great majority of small-holders who expect no more than 1 t/ha, the cost of hiring work animals could amount to about 25% of the gross income from rice.

By making work animals available, rice production could be increased substantially, particularly in the southern and western districts. Efforts in this direction could include: selecting and breeding of appropriate animals; training of work animals and farmers in the diverse agricultural practices that can be undertaken with animal power; advising the owners and handlers on the up-keep of the animals; design and development of animal-drawn tools and implements; and educating the owners in the advantages of keeping work animals.

MECHANIZATION

Except in a handful of tiny irrigation projects initiated by the District Offices, the use of fuel-powered agricultural machinery in the region is extremely rare. In these projects only about 25 ha of rice are cultivated using tractor-drawn ploughs. The objectives of those projects are dubious and performances unsatisfactory. The projects demonstrate vividly the ineffectiveness and inappropriateness of the use of tractors in growing mbuga rice under the prevailing conditions. In the UNDP/ADB-funded Mwamapulli irrigation scheme in Igunga District (the only irrigation scheme of such a scale in the entire region) it is planned to grow 600 ha of rice intensively (more than two crops per year) using mechanization. For agricultural mechanization to be economically viable, high value crops need to be grown intensively using high-yielding varieties accompanied by costly but necessary inputs.

Before encouraging farmers to use agricultural machinery, on a regional basis at least, there is much preparation to be done. This includes the establishment of regular supplies of fuel and spare parts, training of mechanics and operators, training of farmers in the cultivation of high tech varieties, provision of extension facilities, guarantee of irrigation water, establishment of input distribution networks and price control mechanisms, provision of crop storage and marketing facilities, and the formation of pricing policies. Most of these facilities hardly exist in the region and any attempt to introduce agricultural mechanization in the short to medium term in to the region will be premature and irresponsible.

LAND TENURE

Land tenure is based on the principles governing 'usufruct'. Given the overall low population density and the vast areas of uncultivated land (see Tables 3 and 4), land tenure does not, at first, appear to be a serious constraint to agricultural production. However, land tenure as practised in reality, together with the effects of villagization, migration of farmers within the region and the increasing use of work animals, make the situation more complex than it appears (for details see Appendix 1).

There are large areas of unused mbuga land and, under usufruct, this land cannot belong to any individual and should be freely available for anyone from the respective village to use. In almost all of the villages visited during the consultancy, it was revealed that all mbuga land is 'owned' by individuals, whether cultivated or not.

Significant difficulties might sometimes be encountered in attempting to secure a piece of mbuga land for development. The broad economic as well as financial cost of obtaining mbuga land is nevertheless small compared with the benefit expected from rice growing. Few farmers appear to have realized this yet, and the number currently attempting to secure rice land is small. With the labour shortage, the potential demand for mbuga land for rice growing is small compared with its regional availability. Land tenure of mbuga land is therefore not yet a hot political issue. The few who have realized the value of rice growing and have work animals can secure large extents of mbuga land, sometimes causing resentment among others.

However, the rapidly increasing importance of rice is beginning to cause pressure on mbuga land in some districts. If the present labour constraints were alleviated, say by increased availability of work animals, the demand for rice land could rise sharply, possibly leading to disputes over land. Although the government could take steps to prevent this, under the currently practised (as opposed to the official) tenure procedures consolidation of land could occur; and the benefits from increased rice production would not then be fairly distributed among the farming population. Many farmers already claim that lack of free and easy access to mbuga land is one of the factors preventing them from either starting or expanding rice cultivation. The seriousness of the land tenure problem is difficult to assess as few farmers have attempted and failed to secure a piece of rice land. Furthermore, the degree of flexibility and the interpretation of the general principles when administering land tenure probably vary significantly among villages in the region and the scope of this consultancy did not allow a detailed study.

The ownership of communal land under usufruct means that it cannot be sold by individuals. However, during the village visits many cases were noted where land rights had been transferred from one individual to another for payment of some kind, usually involving cash. A landless villager is entitled to have access to a piece of village land for cultivation and can usually obtain this through negotiations with the current owners. Village elders often participate in these negotiations and can, if necessary, put pressure on land owners to release land for redistribution. Discussions on the amount and nature of compensation for the transfer of land rights dominate these negotiations but they are conducted in a friendly manner with community spirit. When the person seeking land is not from the village, it appears that often a more commercial approach is adopted. If unclaimed land is available in the village, the elders can freely allocate such land to the landless.

In some cases the validity of the agreement may be only temporary and then the landless villager periodically (usually every year) negotiates the terms of compensation and, more importantly, the location and size of the plot. Having to shift from one locality to another because of land tenure problems could act as a further deterrent to potential new rice growers.

Mbuga land varies in the productivity with which rice can be grown, some areas being totally unsuitable. At present, these differences are hardly considered when mbuga land is allocated or 'bought' and the most productive parts are not always developed first. In future, if mbga land is to be incorporated into the village planning programme, these variabilities need to be taken into account when land is re-allocated. Land tenure in relation to water resources needs to be examined and perhaps changed so that development of these resources is not hindered. The tenure position with regard to, say, the rights of way for canal traces and the rights to harness water from, and discharge it to, surrounding land are not clear.

SOME ENVIRONMENTAL ASPECTS OF RICE GROWING

Mbuga landforms are not prone to accelerated soil erosion and growing rice in them would conserve soils even better. The harnessing of water from gullies for irrigation would give some scope for checking the limited natural erosion that occurs.

When facilitating increased surface runoff from the upland areas by improving the micro drainage systems as advocated by this consultancy (see section on water resources development), there is a risk of increased soil and gully erosion. With appropriate measures this can, and must, be controlled.

Mbuga ecosystems are ideal breeding grounds for vectors of such water associated diseases as malaria and schistosomiaisis (*Bilharzia*). Bodies of sluggish and/or stagnant water already exist in the mbugas and increasing the area of bunded paddy fields might not by itself have a significant impact on the spread of such diseases. However, the frequency of visits to these areas associated with greater use could substantially increase the prevalence of these diseases in the human population. Malaria is already widespread in the region. Bilharzia is apparently not common but, as it is prevalent in the country, there is a potential danger that it may become established in the region. Any formal programme designed to increase rice production in Tabora Region should contain a subprogramme to combat these existing and potential public health hazards.

Section 4

Water resources

THE PROBLEM AND THE CHALLENGE

Since the rainfall in Tabora is inadequate in quantity and unreliable in its timeliness, the challenge for rice growing in the region is to harness and store supplementary water, and to supply it in the right quantity at the right time to satisfy the crop demand. Various measures can be taken to reduce the risk of crop failure due to droughts and also to expand the present area of rice cultivation by relaxing the prevailing constraints.

This section deals with the hydrologic and irrigation engineering aspects relevant to the availability, harnessing, delivery and efficient usage of water.

HYDROLOGY OF TABORA REGION RICE FIELDS

Rainfall deficiency

The monthly water requirement of rice grown in Tabora Region is about 175-200 mm and the total needed during the crop's six-month duration exceeds 1100 mm. The mean annual rainfall in the region, though concentrated in the same six months, is only about 700 mm in the north and about 1000 mm in the south. If allowance is made for non-effective rainfall, direct precipitation can at most provide about 50% of the total crop water requirement in an average year; this takes no account of field losses.

The root system of rice is shallow so the upper crust of the soil must be kept moist for most of the growing season. The quantity and timeliness of the water supply are probably more important for this semi-aquatic crop than for any other cultivated crop.

In the region, rice seems to be cultivated annually on an average of 50,000 ha or more of land. There are hardly any conventional irrigation schemes and most of this rice is grown in the north and north-east of the region, where the rainfall is lowest and most unreliable. Obviously, the water deficit (crop water demand less effective rainfall) is being met by sources supplementary to direct precipitation.

Land and water regimes for rice growing

Rice grows on a wide range of landforms affected by an equally wide range of hydrologic conditions. Although important rainfall is often not the deciding factor when growing rice. The ecosystems of some parts of the region's mbugas have proved to be highly suitable for rice in spite of inadequate rainfall.

The characteristics of mbugas that amply compensate for the inadequacy and unreliable distribution of the regional rainfall are:

- the relative ease with which surface water can be harnessed from the surrounding lands;
- the shallow hardpan soils on the adjoining upland slopes which induce lateral interflow;

- the presence of consolidated sandy-clay layers in the mbuga soils which intercept vertical drainage;
- the sluggish drainage characteristics (e.g. shallow longitudinal and cross gradients, thick vegetative cover, lack of pronounced drainage paths, wide flow cross-sections causing sheet flow) of the mbuga itself which impede surface runoff;
- the relative ease with which water can be conserved within the bunded fields.

In some places these favourable characteristics are sufficient to facilitate rice growing without the need for extensive measures to modify the natural soil and water regimes. These favoured zones are obviously the first to be exploited and in Nzega District, for example, few such zones remain to be exploited. In the western and southern districts, however, there remain ample opportunities, in spite of the slow but steady exploitation of these zones by migrants from the north-east of the region.

For rice growing purposes, the suitability of the prevailing ecosystem varies considerably among the different zones within a given mbuga and, to a lesser extent among corresponding zones in different mbugas. There are also differences between one cropping season and another at a given site. Although the landform itself is static at a given site, the ecosystem as a whole is dynamic because of the varying characteristics of the weather, particularly rainfall. A site favourably located (say in the phreatic zone) for receiving interflow will, for example offer excellent conditions for rice in a year characterized by rain of low intensity well distributed over a long period, even if the total amount is somewhat below average. In the same year, however, a crop grown at a site located towards the middle of the same mbuga with the hope of receiving flood runoff would be at a disadvantage. In a year characterized by infrequent, short duration, high intensity rain the situation would be reversed.

Sources of supplementary water

Other factors remaining constant, the suitability of a given mbuga site for growing rice will depend on how efficiently the land unit can secure crop water in response to the varying characteristics of the rainfall. Possible water sources additional to direct rainfall are as follows:

- overland flow derived from upland areas
- overland flow derived from upstream mbuga areas
- seepage water (interflow) from upland slopes
- shallow ground water in the mbuga depression zones
- upland flood runoff contained in gulleys
- mbuga flood runoff contained in streams/ditches
- base flows contained in mbuga ditches
- irrigation water supplied through conventional means, e.g. pumped
- ground water, reservoir stored water or run-on river flows.

Many sites have access to more than one of these sources of supplementary water, although one or two may be dominant. Sites vary in the efficiency with which water can be harnessed from different sources and this also varies from year to year at the same site according to rainfall characteristics. Without necessarily going as far as providing conventional irrigation, the ecosystems of some zones of mbugas can be modified to increase the quantity, and improve the timeliness, of water available for growing rice.

SUPPLY REGULATION

Supply-demand imbalance

Rice has a more or less continuous water demand of about 6 mm/day over most of its growing period. With its shallow root zone, rice cannot depend exclusively on soil moisture storage unless rainfall is frequent, more so than in Tabora Region. Like rainfall, the supplementary water sources already listed do not supply water continuously. To satisfy the continuous crop water demand, an adequate amount of water needs to be harnessed from one or more sources and then regulated through surface and/or sub-surface storage.

From the hydraulic and hydrologic aspect each of these sources has specific characteristics and the techniques necessary to develop them will therefore be somewhat different. In order to understand the relationship between these characteristics and the way in which the sources can be developed, they can be grouped under the headings of surface runoff, interflow, and ground water.

Surface runoff in general takes place simultaneously with the rain and, depending on the catchment and storm characteristics, may last from a few minutes to several hours after the rain ceases. Although storm runoff from small catchments does not last much longer than the rainfall itself, if a large enough volume of surface runoff were harnessed and stored, say in bunded fields, the crop would have a continuous supply of water between rains.

Interflow or seepage water will usually be available for a much longer period than surface runoff but the rate of flow will be smaller. In principle, there is therefore less need to store seepage water in bunded fields but, in practice, this must be done to maximize the area of cultivation through efficient use of water and minimize the risk of crop failure at times of unfavourable rains. Engineering measures can also be undertaken to increase the volume as well as the rate of flow. These are described under 'Water resource development'.

When the only supplementary source is shallow groundwater (a swamp-like situation), there is little to do to develop the source. Shallow groundwater is usually present in depression zones in the middle of mbugas. These sites, however, are vulnerable to prolonged inundation which interferes with the timing of agricultural activities, causes crop damage and makes access difficult. Engineering works can be undertaken to ameliorate the situation.

Scope for improvements

The vagaries of rainfall mean that the total area which can be cultivated reliably with only one source of supplementary water will be small. A considerably larger area of mbuga land could be brought under rice cultivation if water was harnessed from multiple sources. Apart from increasing the area of rice cultivation, development based on such a strategy, would also reduce the risk of crop failure caused by water stress. For example a site with modest chances of receiving interflow as well as surface runoff in an average year is adapted for varying rainfall conditions. In years characterized by intense, short duration storms this site will benefit from receiving above average surface runoff to compensate for the shortage of seepage flow. During other years with low intensity, long duration storms the site will capitalize on its ability to receive above average seepage flows.

By using the sources of water available in mbuga ecosytems in a complementary manner, the amount of rice cultivated could be increased significantly. If in-field water storage is also facilitated, at least from the point of view of land and water availability, there is substantial potential to grow more rice at risk levels well within limits acceptable to farmers.

In attempting to maximize rice production it is important not only to exploit water from all the available sources but also to use it in a controlled manner involving storage, conservation, fair distribution and efficient in-field use of water. Field levelling and bunding are simple means towards such controls.

APPROPRIATE LOCATION, BUNDING AND LEVELLING OF RICE PLOTS

Field levelling and 'bunding' (the building of an earth embankment, or 'bund', around the field boundary) allow water to be stored, conserved and made available to the crop in a controlled manner. The extent to which the Tabora Region rice growers exploit this opportunity, the problems they face and some possible improvements to the existing practices are discussed below.

Bunding of rice fields and its associated levelling of land bring about a considerable change in the water regimes of those fields. The overall effect is that runoff water, originating either from the field itself or from the surrounding land in the form of overland flow or seepage, is retained in the field to be made available for the crop as and when demanded. In-field water storage is essential for growing rice in ecosystems with prolonged dry spells.

In-field rain water storage facilitated by the field bunds can regulate the supply over time but this alone cannot guarantee acceptable crop yields when the total effective rainfall is far short of the total crop demand. The depth of water that must be stored in fields depends on the crop water demand of approximately 6 mm/day, field losses (leakage through bunds and deep percolation in particular) and, above all, on the frequency with which the stored water is expected to be replenished. When growing rice with the guarantee of irrigation, the maintenance of about 10 cm in-field storage is common. In Tabora Region dry spells lasting a month or more may occur. To safeguard against these, the in-field storage should be at least 20 cm, provided that the deep percolation rate in these fields does not exceed a few mm/day.

In 1987, for example, a four-week long dry spell occurred from the end of March to end of April but most of the rice grown in bunded fields with adequate storage survived. In this year of heavy rainfall the bunded fields were full of water at the beginning of the drought and even rice planted in fields less favourably located for receiving supplementary water survived the drought*.

Most of the region's rice is grown in bunded fields except some grown under swamp conditions perhaps on an opportunistic basis. The majority of the farmers interviewed believe that rice should be grown in bunded fields; even more believe this is necessary to obtain the best results. Some even believe that bunding is sufficient to ensure a crop. Others, having experienced failure, know that this is not always the case.

Where failure has occurred, the more persistent farmers have opened up new plots and partially abandoned the less reliable old ones. In an average year they will not cultivate all the plots. However, if they are convinced at the beginning of the crop season that rains will be favourable, they will cultivate some of the marginal plots as well. The less enterprising farmers continue to cultivate only their few old established fields but do so only when they think rainfall will be good. A few have become disheartened and abandoned their bunded plots altogether. So, the stock of bunded fields far exceeds the number cultivated in an average year**.

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*It is worth noting that while a rice crop can survive such a drought by capitalizing on surface stored water, upland crops such as maize will suffer from water shortage. A rice crop, though high in water consumption, will have a better chance of combating the drought risks than a maize crop.

**Rainfall is a significant, but not the only, factor controlling the area of rice cultivated in a given year. In 1986-87, in spite of its being exceptionally wet, rice was not planted on about a third of the bunded fields. The farmers interviewed gave diverse reasons (mostly personal) to explain why so many bunded fields remained idle in spite of favourable rains.

Location

The farmers do not all appreciate fully the importance of correct location of the bunded fields but, even if they did, they lack adequate knowledge on which to base their choice of site. Neither the farmers nor the extension officers understand the concepts behind supplementary sources of water, percolation losses, on-field storage and how a rice crop survives the dry spells. Bunding of rice fields seems to have been accepted by the farmers more as a norm peculiar to rice growing than as a measure to improve crop water supply.

In the absence of such knowledge, the best chance a farmer has in locating a reasonable site is to put his bunds near or adjacent to plots which are being successfully cultivated. This process can go on only until either the supplementary water or the land becomes exhausted. Disputes among neighbouring farmers as to land and water rights may also restrict this process.

A few farmers, having recognized certain physical characteristics of the land where rice is grown successfully, go in search of similar land in other parts of the mbuga. An example of this is the locating of plots on the upland slopes where there is a chance of receiving seepage water. Conversely, farmers may avoid sites similar to those known to have performed badly, for example land vulnerable to flood damage. This approach has caused some difficulty because a plot likely to be vulnerable from flooding proves to be the best in a dry year but by the time the year's rainfall status is apparent, it is usually too late to start cultivating rice.

It is clear that because some of the sites are not properly selected to receive and conserve water, the performance of many rice fields is less than optimum. To some extent the variability in productivity from site to site, farmer to farmer and year to year can be lessened merely by advising farmers on how and where to select their plots.

In Urambo and Tabora Districts, where rice cultivation is not as extensive as in the north, there are some opportunities to locate sites where the percolation rate is low and there is a good chance of receiving supplementary water from natural sources which need not be developed, e.g. interflow appearing along a spring line. Once the selection criteria are established, advising farmers on how to identify such sites will not be too difficult. In Nzega District such sites are few and have already been exploited.

The opportunity to increase rice cultivation under less favourable circumstances depends on the ability to modify the hydrologic parameters of the land in the vicinity of the intended rice growing area so that an adequate amount of harnessable water from the upper-lying land becomes available. In addition to taking account of the hydrology of the surrounding land, the techniques and the amount of engineering work necessary to harness the required water must also be considered before deciding to grow rice at these sites.

When new sites are located adjoining already cultivated plots access to supplementary water sources is invariably through other plots, and the water availability as a whole (both in timing and quantity) is subject to the water rights situation prevailing in the locality. Before bunding new plots, negotiations need to be made with those concerned. Trouble may arise: in 1986-87, for example, the supplementary water source used regularly for over 100 ha of rice land in Singida Village in the Nzega District was cut off by the farmers of a neighbouring village. The water was then diverted further upstream to irrigate new land thus depriving the traditional cultivators and leading to village unrest.

Levelling and bunding

Most of the mbuga land is flat and therefore land levelling does not involve movement of large volumes of earth over long distances. By choosing field shapes to suit local topography, the cut and fill depths and the haulage of earth can be kept to a minimum. Mbuga slopes seldom exceed 1% and the maximum depths of cut and fill involved in levelling a plot of say 0.1 ha would be less than 25 cm.

As depths of cut and fill are small, land levelling will affect only the upper soil layers. Where the hardpan is near the surface, land levelling can expose these layers causing the field to become heterogeneous in soils. Poor rice growth occurs where such layers are exposed or are present immediately below the plough layer. The depth of hardpan is a factor to be considered when locating sites to grow rice. However, the average small-holding is 0.5 ha or less scattered in plots of <0.05 ha. Levelling plots of this magnitude should not interfere too much with hardpans, however shallow they may be.

To store water up to a depth of say 25 cm, the height of the field bunds needs to be about 50 cm to allow for settlement and a safety margin to avoid overspill if heavy rains occur when they are already full. To maintain the stability of a 0.5 m high bund, its average width also needs to be about 0.5 m, preferably with a trapezoidal cross section. The rice bunds in Tabora Region in general do not meet these requirements, and in addition to their intended use for storing and controlling of water, they are also used for foot access. Subsidence, leakage of water through the bunds, and over-growth of vegetation are common and the bund heights suggest the maximum amount of water the rice farmers aim to store is usually <20 cm. Simple demonstrations and advice to farmers are all that is required technically to improve the quality of the bunds.

From the point of view of overall efficiency of water use, leakage through internal bunds separating plots within an area of rice land is not too serious because one field's loss is the other's gain. It nevertheless creates difficulties for controlling the water within the plot concerned. This obviously affects crop performance, particularly in drier years, but the farmers do not appear to be greatly concerned. Except for occasionally letting water flow away when their plots are full of water, they have no set plan for attempting to control irrigation water. Few rice farmers control water either in response to rainfall or with reference to the stage of crop growth and no deliberate attempt is made to dry the fields even during harvest. In May 1987 it was noticed that many fields were full of water while harvesting was in progress.

The distribution of water within a patch of rice cultivation is on a field-to-field basis through notches cut into the field bunds. A farmer cultivating a plot in the middle of this patch has no way to control the water entering his plot but must accept whatever his upstream neighbour discharges from his plot. Similarly, once his plot is full he has no option but to breach his downstream bunds and release the excess water. In the absence of inlet and outlet canals, bunding alone can provide little control of field-to-field water distribution. Bunding and levelling nevertheless ensure even distribution and allow uniform crop growth within the plot. As the overall topography is flat, the drop from one bunded field to the next is small and the back scour at the water exits is not severe. Gully formation through the bunded fields is unlikely even during heavy storms.

Besides facilitating the storage of water supplies, bunding has several other advantages for rice growing. When the soil is moist to wet, land preparation becomes easier. This is of particular relevance to Tabora Region where the dominant sandy-clay soils are extremely hard to work when dry and where hand tools or, to a far lesser extent, simple animal-operated equipment are used for ploughing.

Wet land preparation and flooding simplify weed control. Only a limited number of weed species can grow and compete with rice under flood conditions. Except in those rice fields where no attempt has been made to weed, the bunded rice fields in Tabora Region are relatively free of weeds. In areas where proper bunding and levelling are not carried out (mostly on the phreatic and depression zones) weed growth is excessive. Wet rice cultivation increases the availability of plant nutrients, particularly nitrogen and phosphorus. Bunding and levelling also check sheet and gulley erosion, although soil erosion is not a serious problem in the rice growing areas of Tabora Region.

CURRENT WATER HARNESSING PRACTICES

Use of sub-surface flow

The most common supplementary source of water for growing rice, at least as observed in the wet year of 1986-87, is the seepage flow emerging from the upland slopes and entering mbugas laterally. A spring line as such is not always easily visible but the uppermost flooded rice fields are probably at, or just above, the spring line. Except for locating their rice plots appropriately along the slopes, the farmers do not appear to do much to secure seepage flows. The position of the spring line will move depending on the season's rainfall, and with unfavourable rains the uppermost plots will not benefit from this source. Locating the fields further down the slope will not necessarily guarantee that they will receive seepage flow either, because such fields will only receive water after the higher fields are fully satisfied.

In quite a few villages in Nzega District, for example, a large proportion of the lower slopes of the upland area have been terraced and bunded for rice production. Some fields are located far up the slope, above the level of the spring line that could be expected in an average year, and will benefit from seepage water only when the rains are better than average. Below the spring line, but still on the slope, large areas are also likely to be cultivated under rice. When there are so many fields to catch the limited seepage water available, no part of this resource is likely to be wasted even at times of exceptionally favourable rains. Seepage water supplies are variable and farmers face considerable uncertainty concerning the availability of supplementary water from this source.

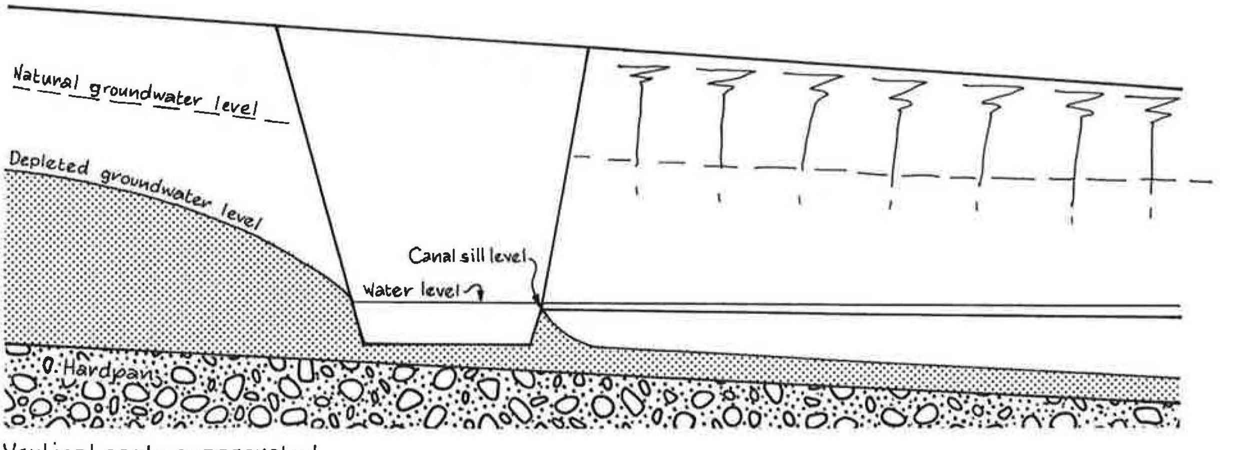
In many villages where rice is not cultivated so extensively, considerable amounts of seepage water remain untapped, yet some fields do not receive adequate water because of their inappropriate siting. Some farmers seem to appreciate the problem associated with the movement of the spring line up and down the slope, and have attempted to fragment their rice holdings and scatter them along the line of slope to spread the risk of crop failure.

The distribution of water among the plots located on the upper slopes is generally on a field-to-field basis, but in some cases a few canals or drains were found to be operative. Whatever the system, the pattern by which water passes from one plot to another at a given slope location seems to be pretty well established, although it appears to vary widely from one location to another in the same village and from one village to the next in the same district. There do not seem to be general principles for the determination of priorities in allocating and distributing water and it appears that at each site the farmers concerned have established their own unique water distribution pattern by consensus. Sufficient time was not available during this consultancy to study in detail the issue of water rights, particularly as it seems to vary considerably from site to site. At locations where land tenure and water rights are somewhat problematic, 'owning' and irrigating widely scattered plots may not be as easy as it seems.

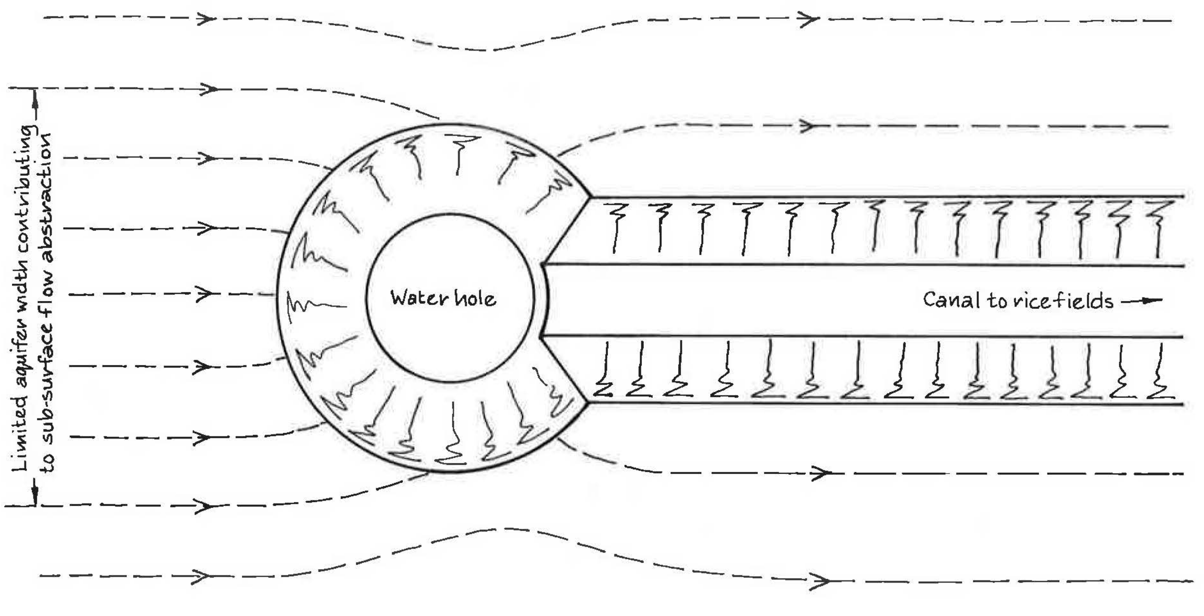
Sporadically, extremely small numbers of farmers have attempted to harness sub-surface interflow by digging water holes and draining the water by gravity to their small rice plots located a few tens of metres down the slope. These water holes are less than a metre deep and up to about 3 m in diameter. The area irrigated by a typical water hole is about 0.01 ha and even this cannot usually be guaranteed. The hydraulic principle upon which this system operates is illustrated in Figure 1. The depth by which the level of the water table

Figure 1

Abstraction of sub-surface flow with dug water hole



Vertical scale exaggerated



upstream of the water hole is depleted is no more than 10-15 cm, and the width of the sub-surface catchment draining into the water hole is only slightly greater than the diameter of the hole itself. The volume of the wedge of the sub-surface flow thus intercepted is therefore small, as is the possible irrigable area. In drier years, when the level of the water table drops below that of the canal (ditch) invert, there will be no benefit to be gained from the dug hole. However, the hole as well as the canal can be deepened. With the water thus obtained plots located further downslope can only be fed by gravity. This would require opening up new land and a deeper and longer canal running down the slope, thus increasing the risk of gully erosion. Deepening the hole and the canal would nevertheless not only increase the reliability of water during the drier years but also provide more irrigation water during favourable times by tapping a larger proportion of the sub-surface flow; the water supply would still be limited, however, by the diameter of the water hole.

In Chamwabo Village (Nzega District) several farmers have communally developed a natural water hole – a pond – fed by a spring. An outlet canal from this pond has been built and some 5 ha of land are under rice, and banana, cultivation. At the time of the visit a similar extent of bunded land,

and about 20 ha of naturally inundated land, remained idle. The mbuga itself covers at least a few hundred hectares, no more than 10% of which is cultivated. Land tenure and labour shortage were the reasons given by the interviewees for not cultivating this land. Yet, up to about 25% of the families in the village were said to have no access to any land, upland or mbuga.

To benefit from the shallow groundwater available, some farmers grow rice in the depression zones, usually located towards the middle of the mbugas. During extended drought spells, crops planted in these areas have the best chances of survival. During the early heavy rains, however, these locations are liable to flood and a young rice crop standing therein is particularly vulnerable to flood damage. Except in years characterized by low early rainfall, nurseries are therefore not generally prepared at these locations. The risk of prolonged and heavy flooding is much less from January onwards, the time when rice is transplanted from the nurseries.

Except in those mbugas where rice is cultivated more or less uniformly all the way to the centre, allowing field bunds to be used as access paths, access to these hydrologically favoured central sites is difficult. For this reason alone, many mbuga depression zones remain unused but when easy access is available, e.g. when a road crosses the mbuga, these become the most favoured sites among the rice growers. In negotiating cultivation rights the price for such lands could be several times higher than that for other land. An example of this is presented in Appendix 1.

Use of surface flow

In some villages there are storage reservoirs in which water is held behind earth embankments (dams), up to about 10 m high, built to span the width of the mbugas (up to about 500 m). The reservoir beds are relatively flat and the average depth of water seldom exceeds 2 m. The dams were built about 25 years ago, some dating back to the latter part of the colonial era. The objective was apparently to provide rural water supplies, particularly for livestock watering. Except perhaps for those few located near population centres, the reservoirs are, however larger than is needed for this purpose. It was suggested that these dams were built under the colonial government during exceptionally bad drought periods under a 'food for work' campaign. This view was apparently contradicted by villagers who maintained that the dams were built with earth-moving machinery.

These reservoirs lack irrigation sluices and canal outlets, being provided only with grassed side-spillways. Spill water escaping from the reservoir is intended to flow from the downstream mbuga periphery towards the centre as quasi sheet flow. Some farmers have located their rice plots to intercept such flows which commence once the reservoir is full, usually in December*. Such water, though discontinuous and not strictly regulated, will be available throughout the remaining rainy season and it is a very useful source of supplementary water, particularly when available to reduce the drought risk during the rice crop inflorescence period in March/April.

From the uppermost rice plots the spill water flow generally spreads and trickles down from field to field towards the middle of the mbuga. There is little use of canal/drain networks to distribute the flow, although relatively short canals link individual plots or clusters of plots at some locations.

Of thirty of these dams surveyed in the region by Brokunsult (1980), five were reported to have been built for irrigation purposes; three were visited during the consultancy. One of them had been breached for several years, but at the time of the visit downstream mbuga land was extensively cultivated both under rice and sorghum (on better drained soils on the mbuga fringes). At the second site visited rice was extensively cultivated both upstream and

*Located away from the centre of the mbuga and towards the upland slopes, some of these plots could well be receiving some upland derived seepage flow also.

downstream of the dam, obviously in the absence of much stored water behind the dam. Very recently a sluice had been incorporated into the dam, and perhaps for this reason there was not much water held in the reservoir. This must have enabled farmers to cultivate rice in the reservoir bed. Downstream of the third site, Idudumo dam in Igunga District, at least 100 ha of rice was grown quite successfully. How much of this success can be attributed to the dam however is difficult to judge in view of the other sites described above, and other villages such as Simbo and Sigili, where extensive rice is grown without the benefit of a dam.

Some of the other reservoirs, described by Brokunsult (1980) as rural water supply sources, were also visited. Except for a very few which are still used to supply domestic water, they are currently being used exclusively for irrigation and perhaps some fishing. Only spill waters are used for irrigation and the total area cultivated at each site is <20 ha.

Three or four irrigation projects were started recently under the auspices of the District Commissioners. At Idudumo, for example, a supply canal and a sluice were constructed with the intention of double cropping some 50 ha of rice using tractors, high-yielding varieties and fertilizers. Severe problems were encountered and in 1987 only 1 ha could be planted in spite of the relatively high investment. Such operations are embarrassing the authorities in view of the success of the Idudumo farmers with no such implements, technology and back-up support. Other projects were said to have suffered a similar fate.

In some villages much smaller community level dams, often not exceeding 2 m in height, have been constructed across small mbugas up to about 100 m wide. Here again the idea is not so much to regulate the mbuga flow but to head it up, release it along side spillways and spread it along the bunded fields. Small mbugas carry relatively little runoff and the area irrigable seldom exceeds several hectares. In addition, as the depth of water stored is very shallow, particularly on the margins of the reservoir, flood recession irrigation is practised quite successfully on the edge of the water spread area in the reservoir.

Some 25 km south of Tabora Town towards Sikonge Village, a recently arrived group of Wasukuma people has built a series of small transverse bunds along a mbuga. Hardly 0.5 m high and some 100 m long, they form barriers across the central part of the mbuga with deliberate breaches (openings) for excess water to escape. Immediately upstream of these bunds are bunded rice fields. The back water effect caused during flood conditions is sufficient for the water to overtop the field bunds and inundate the rice fields. When the flood recedes the water in the bunded rice fields remains trapped therein. Flood recession in these flat-bottomed mbugas is characterized by quasi sheet flow during which little damage is caused to the field bunds. The barrier bund may sustain some damage particularly at the openings, but repairs need only be undertaken when the rice fields need topping up. The cost of repair, made up entirely of unskilled labour, would be no more than a few man-days per barrier. Located in the wetter part of the region, these fields do not demand frequent topping up.

A small number of farmers attempt to harness surface water by building small, crescent-shaped earth embankments, often not exceeding 1 m in height at the highest point, to collect runoff from their micro catchments. Immediately after a few good storms these reservoirs will be full. When drained into downstream rice plots the water in a typical reservoir is sufficient to cover about 0.04 ha to a depth of about 100 mm. During spells of drought these micro reservoirs are usually dry and in wet weather the harnessed water can be stored in the rice plots straight away. The main benefit to farmers would come from using the water left behind to top up the water in the bunded rice plots before the droughts really set in.

In the middle of a few mbugas are well defined water courses, though some may be intermittent and they may also be somewhat 'braided' (subdivided into separate channels). Three years ago in Nata Village (Nzega District), at the initiative of one farmer and later with encouragement and support from the village leaders, the villagers dug a canal to channel the flow in a braided branch of the Manonga River. The canal, with its own branches totalling some 3 km in length, was completed in two dry seasons and opened up 150 ha of new rice land, increasing the village rice area by about 30%. The financial cost was virtually zero and as the opportunity cost of labour is at its minimum during the dry season, the economic cost of the operation was also small. This illustrates what can be achieved in the way of increased rice cultivation by adopting low-cost methodology based on community participation. The achievement contrasts with previous and current irrigation development efforts of government, international development agencies and aid agencies which require capital investment costs of up to US$10,000 per ha to open up land for rice cultivation.

In 1987, farmers in a village located upstream of Singida Village (Nzega District) intercepted the flow in another branch of the Manonga River by diverting it into a community-built canal. Although this deprived Singida Village of water needed for about 100 ha of rice land, it again illustrates what can be achieved at village level at very small financial cost.

The sporadic use of gully flows by farmers was observed during field visits. With rare exceptions, e.g. in Simbo Village, this resource does not appear to have been fully exploited.

WATER RESOURCE DEVELOPMENT

Strategy

Of the region's total rainfall perhaps only about 5% is used for all crop production, rice accounting for no more than 10% of this. This is mainly because the rural population density is low (about 12 persons/km^2), and consequently no more than 15% of the land area, including fallow, is under cultivation.

Rainfall being somewhat erratic, the prospect for rainfed farming for surplus with the limited available labour is poor. There are not many water courses which run for long enough periods carrying sufficient quantities of water to develop off-the-river irrigation, and the upland topography is not suitable for gravity irrigation. Large storage sites for building big dams are not available but the mbuga topography would permit the building of low (but long) dams capable of storing sufficient water to irrigate a few hundred hectares at cropping intensities of up to about 1.25. However, considerations other than those of water resources and civil engineering do not favour such developments.

Given a surplus of mbuga land for growing rice, a strategy to increase cropping intensities would be somewhat incongruous. When foreign capital is heavily invested in conventional irrigation developments, early returns are sought to satisfy economists working according to discounted cash flow principles. Increasing cropping intensities is a favourite option but it demands high tech agronomy (short duration/high-yielding varieties and high capital agronomic inputs) and mechanization, the latter in particular adding even more to the foreign exchange bill. Where the institutions and infrastructure are inadequate for the high tech approach, there is a downward spiral of increased foreign debt, disillusioned farmers and high maintenance bills.

Many government officials and some international development agencies are nevertheless keen to pursue this line of irrigation development. The country's lack of the resources needed for this is so acute that in the entire

Tabora Region, Mwamapuli Dam, is the first and only site to be developed in this way, with almost complete dependence on foreign capital, equipment and expertise and at a per hectare development cost of about US$10,000.

To modernize the existing rice cultivation in the region large inputs of irrigation engineering, agronomy, capital and infrastructure (e.g. markets, distribution systems and institutions for providing training, technical support, agricultural credit etc.) would be necessary. The resulting increase in production would be too small to justify such inputs. Furthermore, only a few such schemes could be undertaken in the country as a whole at a given time.

In attempting to develop regions as large as Tabora with the prime objective not only of increasing rice production but also of ensuring the distribution of benefits widely among the population and villages such a site-specific, high tech, top-down development approach is not suitable. On the contrary, development programmes designed for extensive coverage must be based on simple low-cost technology which is easy to replicate and should rely largely on resources mobilizable within the village. In the context of rice irrigation on Tabora Region, these requirements limit the scope of development merely to assisting the farmers themselves to undertake marginal improvements to their existing practices. Although perhaps lacking in appeal to technocrats, such a programme would, from the point of view of regional development, generate large social and economic benefits; returns to the small amount of capital investment necessary would be huge.

The norms under which rice is currently produced in the region are the most appropriate for producing the best results, given the land and water regime, technical know-how and socio-economic status of the farmers. This is particularly so in relation to the input/output efficiency in the Tabora Region. This consultancy will therefore place little emphasis on conventional, high tech, capital intensive systems as a means of securing supplementary water to grow rice. What is advocated here is the improvement of existing practices which can be undertaken by the farmers themselves without much external material support but with some technical assistance.

There is scope for improving all aspects of existing development practices for supplementary water resources. Improvements include favourable siting of plots to receive and retain water, conservation and control of on-field storage with field bunds, harnessing surface and sub-surface flows, flood control and efficient distribution.

Siting

Plots relying upon surface runoff or interflow should be sited on relatively impervious soils. Topographically they should be located at a suitable elevation with respect to that of the source to allow for hydraulic head loss during the conveyance of water from the source to the plots. Rice plots dependent on shallow groundwater may be sited at depression zones where the soil characteristics permit the relatively shallow rice roots to tap groundwater and also where the depletion of the water table during drought spells is not excessive.

During Phase I of the proposed technical assistance programme (see Appendix 3), relevant site-specific parameters which can be correlated with successful rice growing would have to be determined. These would include: permeability of soils; fluctuation of groundwater levels above the seepage zones and in depression zones; and the frequency at which, and total area on which, rice can be reliably grown with seepage flows. Rainfall, catchment, and aquifer characteristics which respond to surface runoff, interflow yields and groundwater levels would also need to be studied.

With the results of these studies, simple guidelines could be prepared to assist farmers in locating their plots. This work would also be useful in modifying the methodology proposed for the use of village planners in their assessment of village rice growing potential (see Appendix 2).

Field bunding

Some inadequacies observed during the field visits and some suggestions on how to improve field bunds are mentioned in the penultimate sections. Studies could be undertaken with a view to recommending appropriate dimensions and specifications for field bunds to be used under different circumstances, i.e. in drier or wetter parts of the region, for the single or combined purpose(s) of water storage and control, foot access and flood control.

Field levelling

The extent to which field levelling needs to be improved could be identified and the agronomic benefits to be derived from better levelling could be assessed and demonstrated. While demonstrating the positive effect that good field levelling has on crop yields through facilitating uniform crop water availability and weed suppression, aspects of manual and animal ploughing and levelling could also be investigated.

Field distribution

Investigations could be undertaken to determine the feasibility of having improved canal distribution networks within the rice zones with the aim of increasing water use efficiency through better and more equitable sharing of water. Simple principles could be generated to guide farmers in simplifying their local water allocation practices. This work would be particularly relevant in those villages where rice is grown extensively but people complain of water shortages.

Interception of interflow

More reliable and bigger volumes of lateral sub-surface flows (interflows) could be harnessed using an interflow interceptor canal, whose function is illustrated in Figure 2a. The principle is similar to that currently practised by farmers harnessing interflow through dug water holes (see Figure 1).

A long trench (compare dug hole), say up to about 1.5 m deep, cut near the seepage zone more or less parallel to the topographic contour and perpendicular to the sub-surface flow path, will intercept and collect interflow. The lower end of the interceptor could be connected to a supply canal which delivers the water to the lower-lying rice fields. By controlling the level of water in the interceptor the rate at which sub-surface flow enters the interceptor canal can be varied (Figure 2b). This could be achieved by releasing or ponding water in the interceptor by means of a simple stop log (preferably vertical needles) arrangement installed at the downstream end of the interceptor.

By such controls, the groundwater levels in the perched aquifer could also be controlled thus allowing some sub-surface storage regulation. In exceptionally wet years, the interceptor could be used as a drainage canal to lower the upland groundwater levels which threaten upland crops (particularly maize) with impeded drainage. During the wet year of 1986–87 much of the upland maize crop was ruined because of waterlogging.

The sub-surface flow interceptor can also be used to intercept surface runoff. If so desired, designated surface water entry points can be established to ensure safe entry of surface runoff without causing bank erosion.

In exceptionally dry years, by maintaining high water levels in the interceptor canal, say by ponding surface and sub-surface water, adequate soil moisture levels for growing the locally preferred maize and other upland crops can be achieved. Interceptor canals designed for such multiple uses may be lined with clay on the side facing the aquifer.

Figure 2a

Surface and sub-surface flow interceptor arrangement

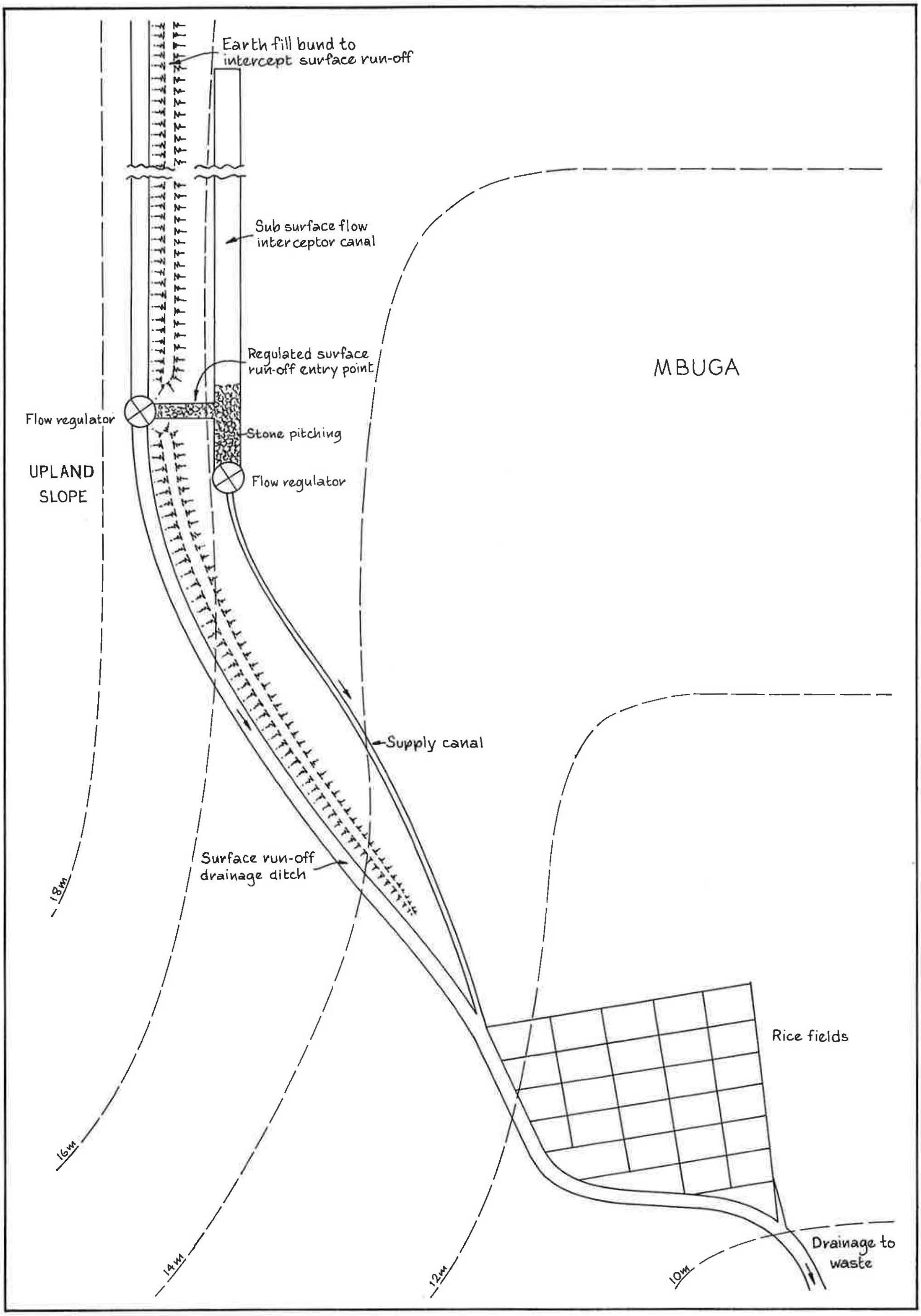
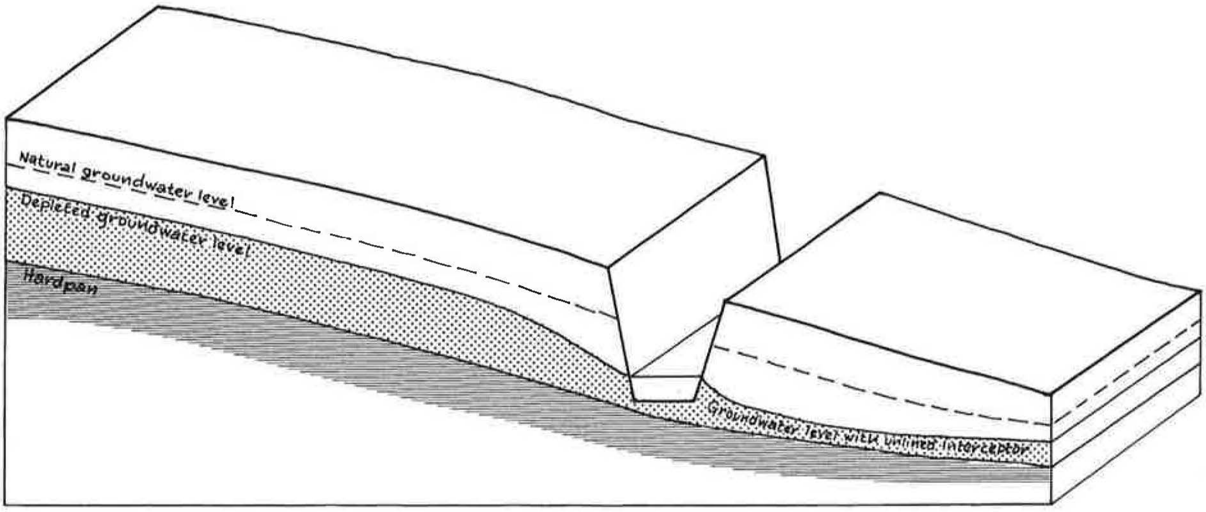
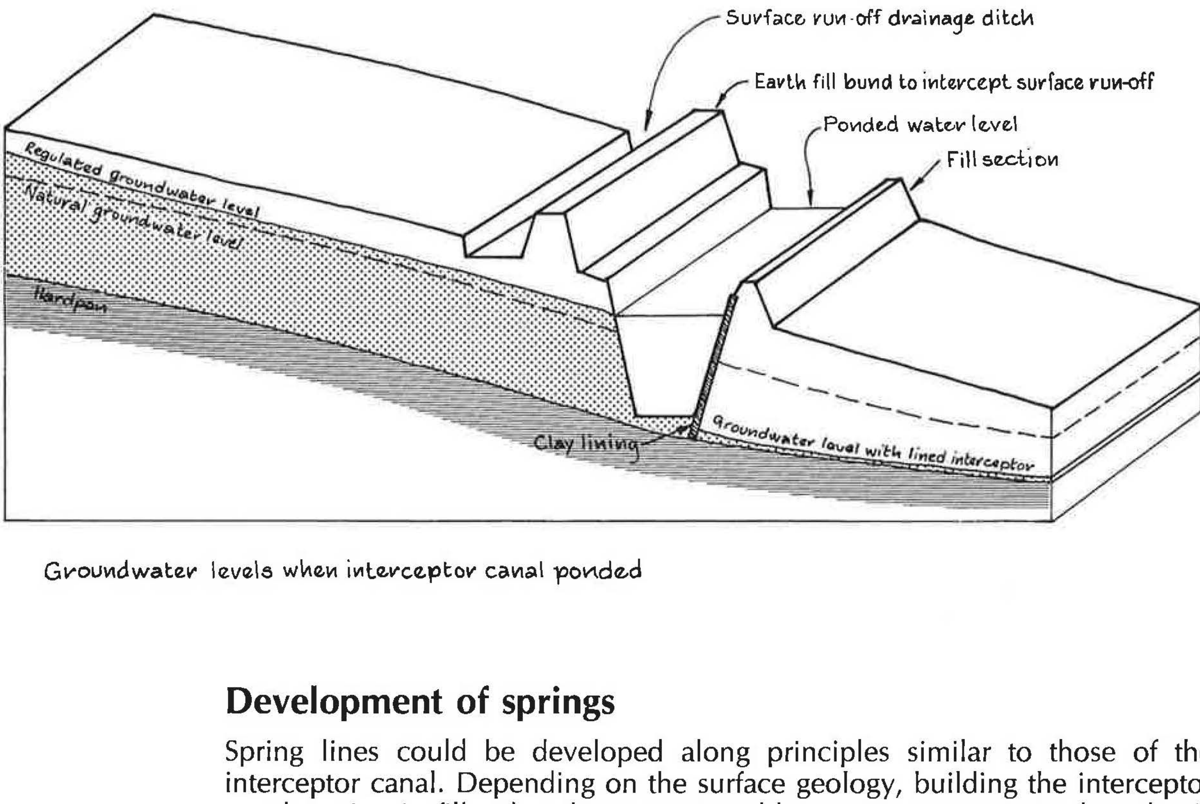


Figure 2b

Interceptor canal as a sub-surface flow regulator



Groundwater levels when abstracting subsurface flow



Groundwater levels when interceptor canal ponded

Development of springs

Spring lines could be developed along principles similar to those of the interceptor canal. Depending on the surface geology, building the interceptor canal section in fill rather than in cut could sometimes prove simpler. This is particularly so when the spring flow is emerging above hard lateritic/granitic outcrops. Alternatively, an interceptor canal could be built along a line roughly parallel to the spring line but further up the slope to trap the interflow before it emerges as spring flows.

A point source spring (water appearing at a localized point rather than along a line) could be developed along the principles of the dug well if the geology allows. Otherwise, a shallow masonry wall founded on the hard rock could be built around the spring, incorporating facilities to release the water into a supply canal.

Development of shallow groundwater zones (mbuga depressions)

The basic problem at these sites is the vulnerability of the crops to flood damage; earth bunds (up to about 1.5 m in height) built on the peripheries of these zones could give protection. Facilities for water to enter and leave these zones in a controlled manner to provide supplementary surface water requirements or drainage could be incorporated into these bunds. Provision of foot-paths above the flood level would facilitate access.

The region has a large amount of such land that could be cultivated under rice. Although the amount of earth work involved in developing these sites could be relatively large, such developments might nevertheless prove to be economically very attractive, because the risk of crop failure due to drought is at its minimum at these sites. Also, in depression zones where groundwater levels do not deplete excessively during the dry season, rice nurseries could be prepared even before the start of the rainy season, thus alleviating labour bottle-necks, and giving the crop a better chance of success.

All the earth work involved can be carried out manually and with animal draught power. It is recommended that these works be undertaken using animal- or labour-intensive methods during off-peak labour periods to keep financial and economic costs low.

Development of existing storage reservoirs

Irrigation developments based on reservoir storage were condemned in this report on the grounds of high capital and foreign exchange costs. If the cost of building the dams has already been incurred, however, the use of water behind them is not inconsistent with appropriate development. Two modes by which the reservoir-regulated flows can be used for irrigation are shown in Figure 3.

By improving the spill canal and by building lateral distribution canals the spill waters can be used more efficiently. The water stored below the spill level could also be extracted using sluice controls. The building of outlet sluices is beyond the level of village-based technology, but the cost, particularly in relation to the potential benefits, is very small. Such activities could therefore be conveniently incorporated into a technical assistance programme.

Construction of canals leading from the sluices as well as from the spillway canal could be undertaken by the community. The amount of earth work involved is substantial and a considerable amount of organization would be needed to mobilize the relatively large labour force required. The evidence from villages such as Nata suggests that this can be done, even without external assistance. It is thought nevertheless that some technical assistance to streamline the activities, particularly those of a technical nature, would be desirable.

Except for the use of machinery, the technology adopted by the Department of Irrigation in its attempts to develop a few of these derelict reservoirs on behalf of the District Offices (see Idudumo Dam, page 30) is similar to what is advocated here. As far as the organization of the work and the ownership of the scheme are concerned there is, however, a great deal of difference.

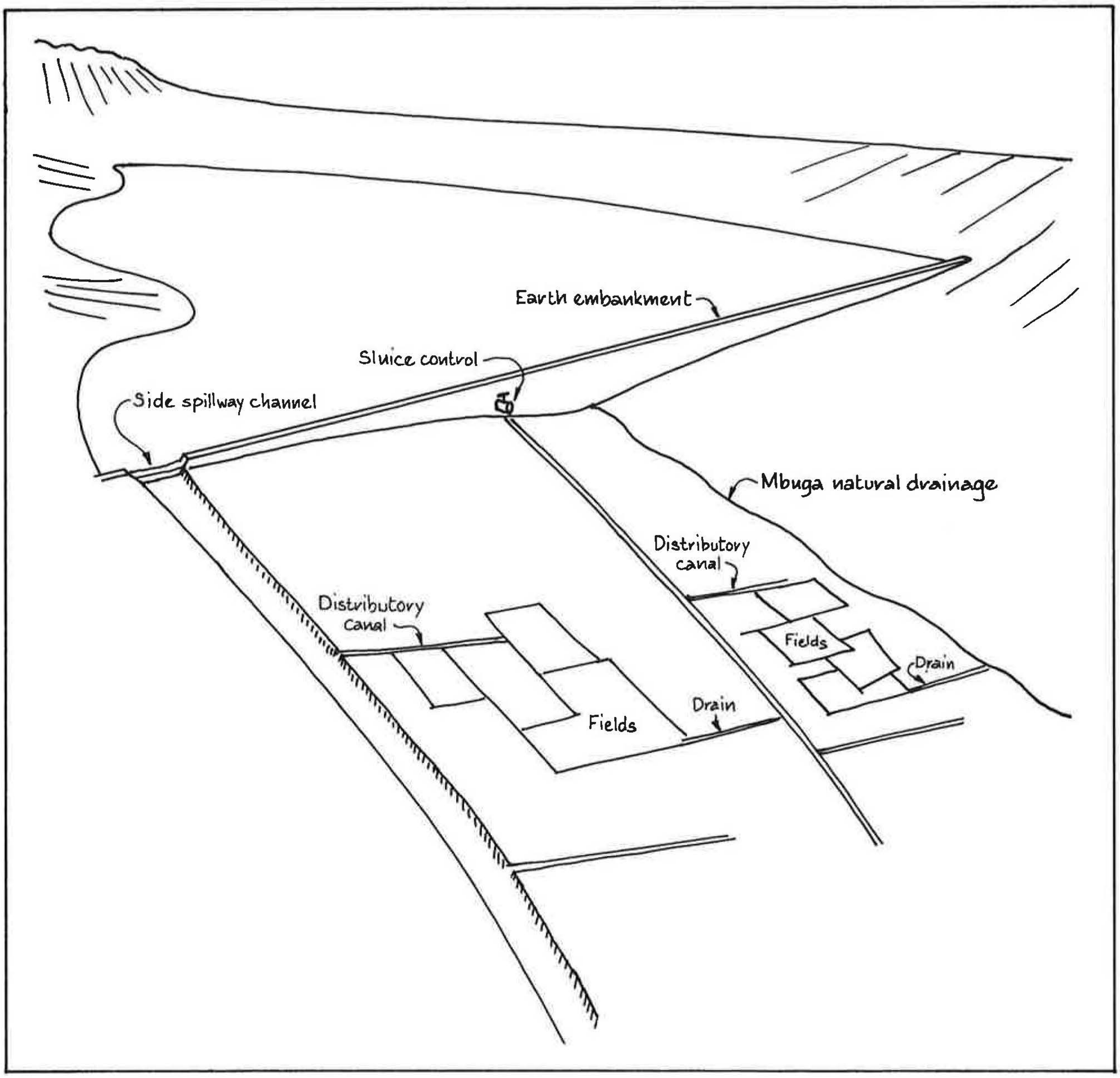
The respective command areas of irrigation water secured from the two sources (i.e. spill water and sluice water) are different and the abstraction of sluice water could deny water for spill water users. Studies on how to distribute water fairly among the different users would have to be undertaken and principles governing water distribution and allocation established.

Village tanks

Where village labour can be mobilized to build the small dams (up to 2 m high and 100 m long) spanning small mbugas as already described, such

Figure 3

Use of reservoir regulated flows



development attempts should be encouraged. The technical principles involved are similar to those of the existing larger reservoirs. Traditionally these small dams have also been used to facilitate flood recession irrigation on land upstream of the dam. This too deserves encouragement. Under the proposed technical assistance (see Appendix 3), the performance of existing village tanks could be improved along the lines proposed for improving existing storage reservoirs (see above), with a view to demonstrating the potential benefits that can be derived from these tanks.

Flood recession irrigation

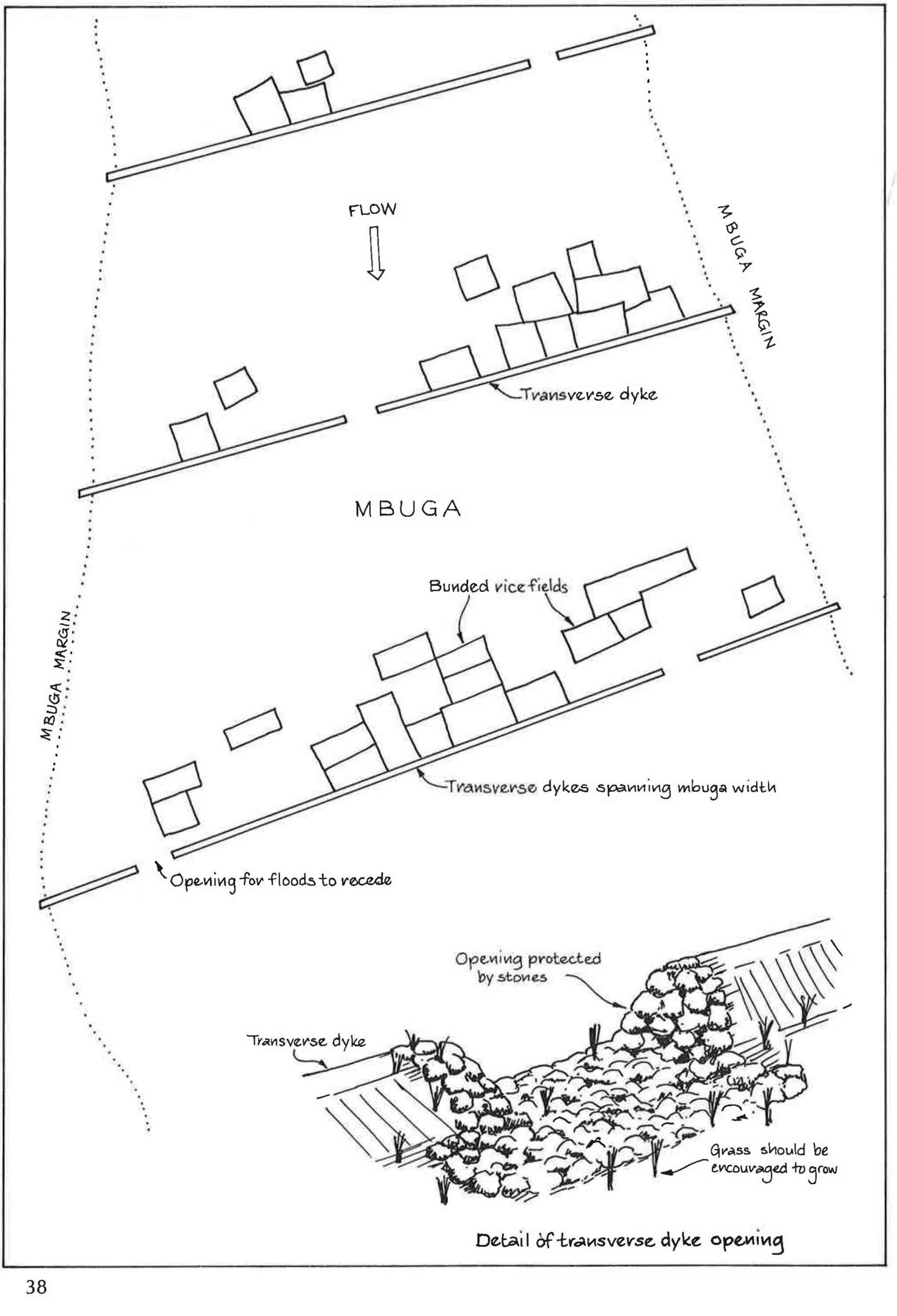
This could be facilitated by any one of the following techniques:

(a) building earth embankments as high as 2 m and allowing water to head up. The land on the periphery of the water spread area could then be developed under flood recession irrigation (see village tanks above);

(b) location of a large number of bunded rice fields across the middle of the mbuga and with some provision for drainage;

Figure 4

Flood recession irrigation using transverse dykes



(c) building a series of transverse dykes, no more than 0.5 m in height, along the mbuga (see Figure 4).

With (b), the usual problems are the prolonged inundation and possible flood damage to crops. The key to improving this lies in the efficient drainage of the mbuga. In those mbugas where fairly well defined drainage channels exist and/or where the downstream hydraulic conditions favour free drainage, this practice could be adopted.

An extensive area of rice is grown by flood recession irrigation in Simbo Village. In mbugas where drainage can be facilitated, and there are enough farmers prepared to plant a significant area spanning the mbuga width, this method can be practised effectively. Care should be taken to check the development of gullies, particularly if water by-passes the bunded rice areas in a concentrated manner. To avoid this, bunded rice fields should cover the entire width of the mbuga flow section.

When developing virgin mbugas to practise flood recession irrigation (b) should perhaps be preceded by (c). When the number of rice plots is too small to cover the entire mbuga width, the building of regularly perforated, shallow bunds across the mbuga width can retard the flow sufficiently to allow flood recession irrigation to be practised. As the numbers of rice plots increase, the shallow bunds would be incorporated into the field bunds. The frequent damage to these bunds already described (see page 30) could be minimized if the flood escape perforations were strengthened with packed stones and brushwood and/or by using flatter downstream bund slopes. The efficiencies of both (b) and (c) will depend to a significant extent on site-specific features such as topography, micro drainage and flood regime. During Phase 1 of the proposed technical assistance, studies could be undertaken to determine the optimum design parameters for building these shallow bunds.

Stream flow diversion

Quite a few mbugas have fairly well defined water courses, albeit often braided. The larger flood flows are intermittent, but small flows (in the order of 0.1 m^3/s or less) continue through most of the rainy season.

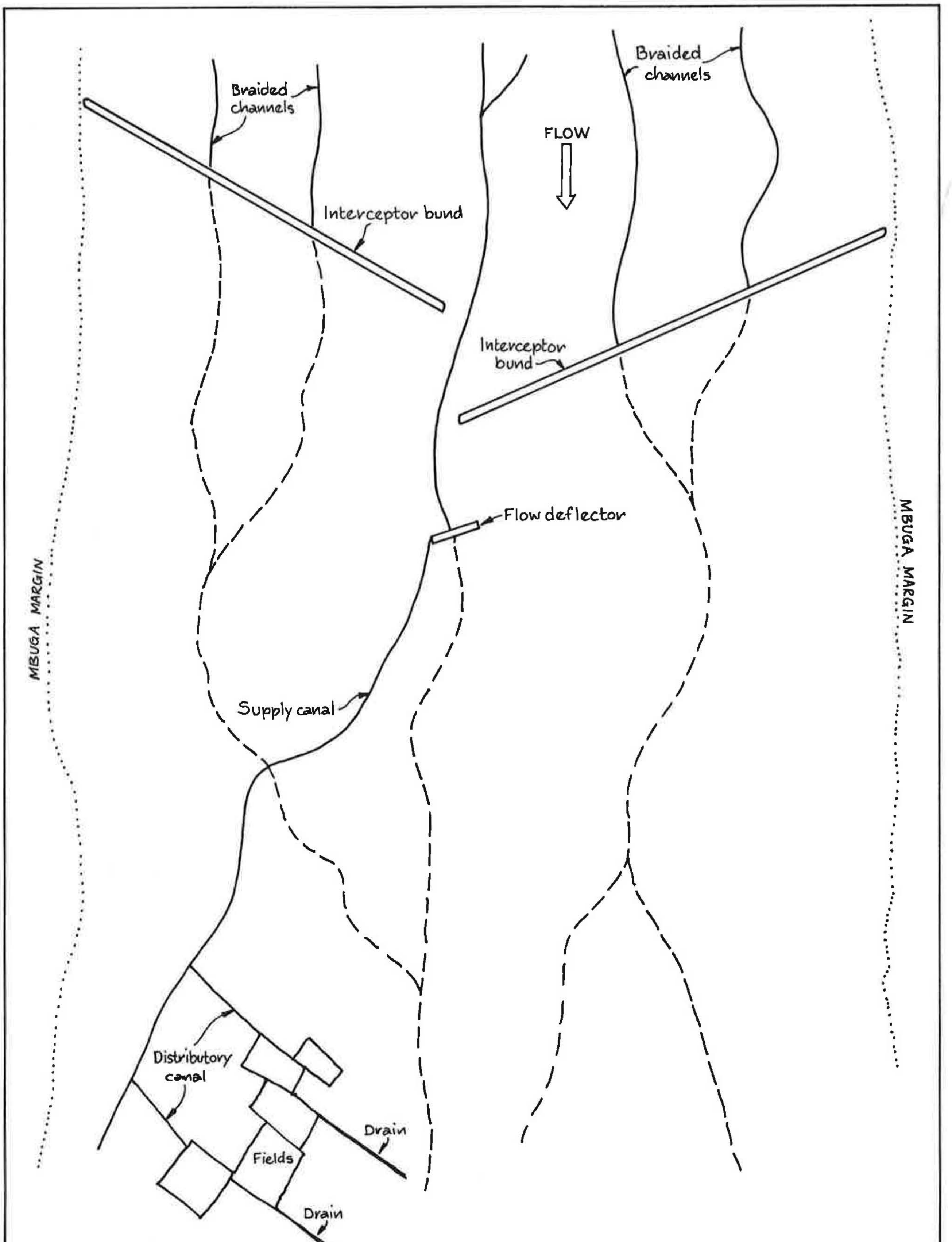
The low flow rates are partly due to impeded drainage. If the base flows in the braided channels were first intercepted and then canalized as illustrated in Figure 5, the resulting flows would be sufficient to provide supplementary irrigation to several scores of hectares. These canals could also be used to divert larger flows during flood conditions and the area thus irrigable could be substantial.

The longitudinal slopes of mbugas being in general slight, the canalized flows would have to extend some distance downstream before gaining command over the irrigable area. This could in some instances interfere with land/water rights, particularly if the canals have to cross village boundaries. If the canals were to carry flood flows with some degree of flood protection, the amount of earth work involved would be substantial. Long canals would nevertheless allow rice plots to be located away from the middle of the mbugas thus ameliorating the access and flood damage problems. The benefits would far outweigh the costs, particularly if appropriate, low-cost construction techniques/methodologies were adopted.

The development techniques are simple, and the bulk of the construction work is limited to earth work. Some preliminary site investigations (topographic and hydrographic surveys) and design work would have to be done first, however. Perhaps because of the inability of farmers to locate appropriate diversion sites and canal traces, the practice of stream flow diversion does not appear to be common in the region. Although the case of Nata Village (see page 31) may be rare, there is no reason why other villages, assisted by preliminary design and community organization, cannot undertake such tasks.

Figure 5

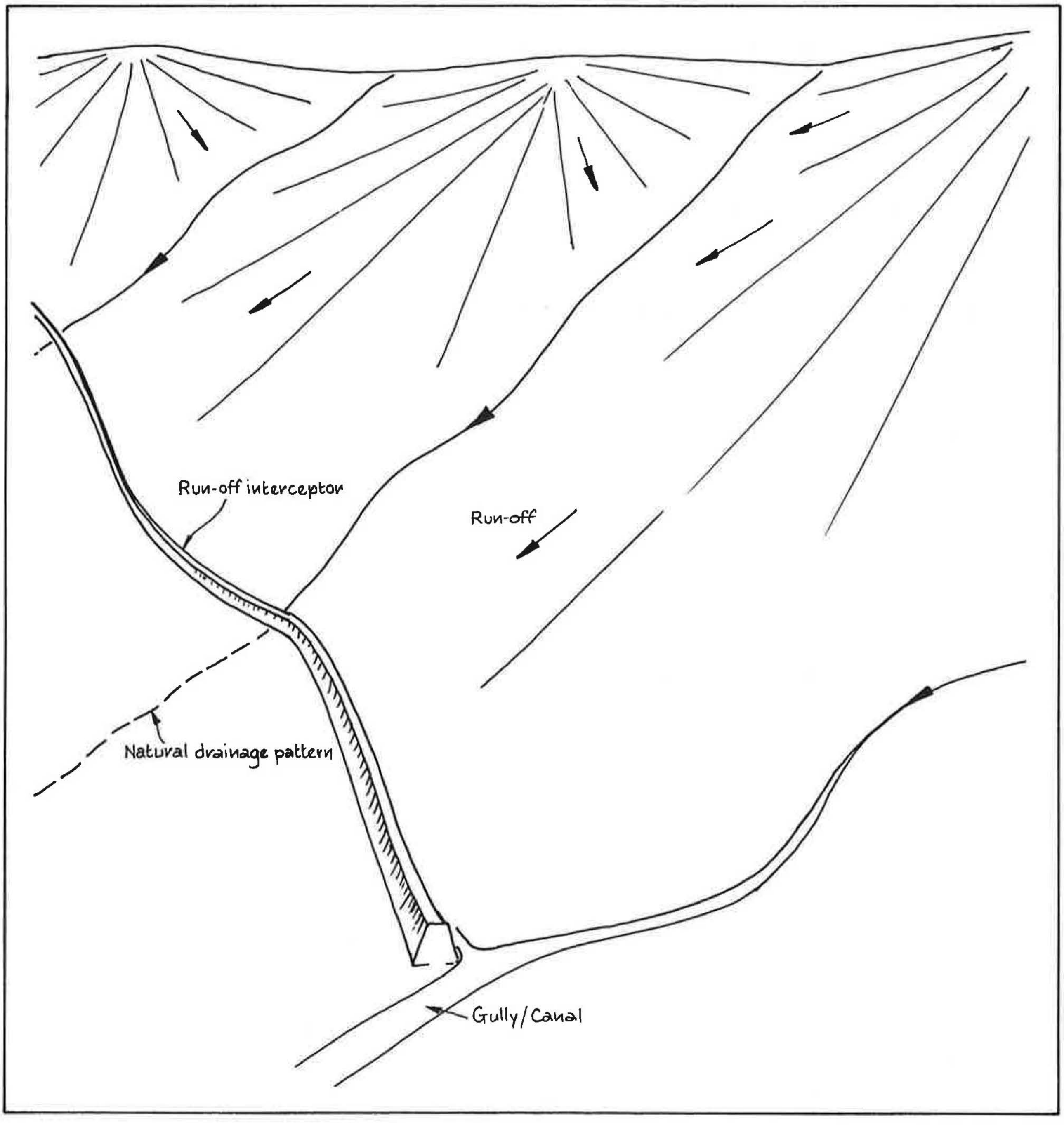
Stream flow diversion and distribution



There is great scope for providing technical assistance to farmers to facilitate the harnessing of stream flows to secure supplementary irrigation for rice cultivation.

Figure 6

Runoff harvesting system



Upland runoff harvesting

Except where crops are grown, the scope for harnessing runoff from most of the upland areas is good. Catchment characteristics such as shallow soils overlying hardpans, outcropping of relatively impervious rocks (granites, gneises and laterites) and steep slopes, coupled with intense storms, produce high runoffs. Undulating topography characterized by broad, almost flat, mbugas separating relatively narrow areas of upland do not, however, allow the high runoff yields to concentrate to form gullies. To harness the upland runoff, therefore, the quasi sheet flow has first to be intercepted and then canalized (see Figure 6). Micro drainage characteristics of the upland areas need to be studied and small contour interceptor bunds (up to about 0.25 m in height) could train the quasi sheet flow into purpose-built canals or the few natural gullies. Unless checked the increased flow entering the gullies will induce erosion.

Section 5

Rice cultivation and village planning

RATIONALE FOR VILLAGE PLANNING

The villagization programme carried out in the 1970s to provide basic amenities such as primary health care, education and drinking water supplies, has led to the deterioration of rural agricultural production in most parts of the country. Villagers were concentrated at the village centres in order to facilitate the provision of these amenities, farmers were separated from their traditional farms by considerable distances and consequently the total area cultivated dropped.

Following the recommendations made by the LRS study team, ODA provided further technical assistance for the re-planning of villages in Tabora Region. Emphasis was on village decentralization. The target objectives were that each village and family should achieve self-sufficiency in food and, with surplus production, become economically viable. This was to be achieved by ensuring fair, equitable and adequate allocation of village land among the villagers. It was envisaged that the amount of land allocated to each family would be calculated on the basis of human carrying capacity (HCC) criteria.

The HCC models designed to assess the amount of land required to support an average family (based on a standard village cropping pattern) were largely based on upland cultivation. This may have been because farmers put so much emphasis on upland cropping and/or because the potential importance of rice production was underestimated by the planners. In these models, any benefit from rice production has been treated rather as a bonus over and above what the village must produce to keep its population viable.

In many villages, there is not enough upland land available to distribute to all the families according the standards demanded by the HCC models. When attempting to plan villages with high population densities, village planners faced a choice between having to incorporate rice production formally into the planning models or to thin the village population. The situation is worse among the villages in northern districts, but it is here that rice production is at its maximum and already accounts for a considerable proportion of the village agricultural production. The population densities in the villages of southern and western districts are not high enough to compel the planners to incorporate rice production into the planning models, but in these villages farmers attach rapidly increasing importance to rice cultivation. The need to consider rice production in village planning is growing fast.

Under the existing planning procedures, a single multipurpose block of upland land is allocated to a family to (a) build their homestead, (b) cultivate upland crops on a rotation basis, (c) plant and maintain woodlots to secure family fuelwood needs and (d) part satisfy the animal grazing requirements. When allocating mbuga rice land, however, such a simple procedure is difficult to apply.

PROBLEMS ASSOCIATED WITH MBUGA LAND ALLOCATION

Only very rarely can rice plots be adjacent to these upland blocks. The allocable mbuga rice lands are often some distance away from the upland farms, and the family holdings would necessarily be fragmented to guarantee at least a partial rice crop in most years*. The idea of allocating a single multipurpose land unit cannot therefore be extended to include rice farming.

Upland blocks are allocated virtually to every family in the village with the hope and belief that such lands will be fully utilized in some way or another, even if not according to the cropping patterns assumed by the planners. Many families in the region do not grow rice, and the mere allocation of mbuga land to them would not necessarily ensure that rice would be cultivated as prescribed in the village planning model.

It has alredy been emphasized that the productivity, and indeed sometimes even the possibility of growing rice at a mbuga site varies enormously from one part of the mbuga to another, and also from one year to the next, depending on the characteristics of that year's rainfall. Under these circumstances, it will be difficult to determine (a) how much rice land would be needed, and (b) where it would have to be located in the mbuga to sustain the overall family rice needs under village planning based on an HCC model.

RICE PRODUCTION VERSUS EQUITABLE LAND DISTRIBUTION

Although the total area of mbuga land in the region as a whole is huge (see Table 3), that belonging to some of the villages is small enough to cause problems when attempting to allocate such areas among the many village families. Because of soil and water constraints perhaps, on average, no more than a third of the village mbuga area can be brought under rice cultivation. Distributed more or less equally, productive mbuga land for an average family would be only about 2 ha.

The most productive rice farms in the region are the larger holdings (say 5 ha), which tend to be cultivated by oxen and managed by serious, relatively rich and experienced farmers. Although such farmers are an extremely small proportion of the regional farming population, their contribution to overall, and, in particular, to surplus, regional rice production is substantial. Marginal returns (measured in cash) from rice production are high, and therefore these farmers are looking for opportunities to expand their rice cultivation. Land allocation formulae as currently being used in allocating upland land, if applied strictly to mbuga land could severely disrupt this efficient production base.

IMPACT OF MBUGA LAND ALLOCATION ON DIFFERENT VILLAGES

In northern district villages most of the productive mbuga land is already developed under rice. Most of the families grow rice, but their holding sizes vary significantly. Equitable allocation of mbuga land is socially desirable, but can only be achieved under such circumstances at the cost of reduced village rice production levels, at least during the initial stages.

In the southern end and western district villages large areas of potential rice land remain idle. Mere allocation of such land among families may not necessarily ensure that it will be cultivated. Except where there are minor land tenure arguments (which have been occurring recently particularly when outsiders attempt to obtain large areas), mbuga land has always been relatively freely available for those villagers who wanted to grow rice. Few farmers in

*Plots need to be located in different hydrologic regions so that at least some of them will receive supplementary water in a given year, whatever the rainfall pattern.

these villages have planted rice and individually they have developed only small areas, often not exceeding 0.25 ha. Block allocation of mbuga land will therefore bring hardly any additional benefits to the individual families concerned, particularly in the short term. Indeed if the process of allocation fragmented the few existing larger rice holdings of the bigger farmers, the losses to total village rice production could be substantial.

Placing limits on rice holdings in these villages would severely curtail the arrival of cattle owning, large-scale rice growers from the northern districts. This would have two undesirable effects: mbugas in the southern and western districts would lie idle in spite of having the best rice growing potential in the region, and the pressure on land, both upland and mbuga, in the northern districts would rise even faster.

PLANNING ENTITY: VILLAGE AS OPPOSED TO FAMILY

Under the currently practised mbuga land tenure and agricultural systems, it is unrealistic to expect that every family will incorporate rice farming into its individual cropping pattern. Village planning therefore cannot be undertaken on the basis that each family will be sustained by a cropping pattern that includes an element of rice growing. On the other hand, since rice contributes to a significant extent towards the total village agricultural production, it cannot be disregarded during village planning. If the village as a whole were to be regarded as the planning unit (as opposed to the family), rice production could be brought into an aggregate village planning model.

MBUGA LAND ALLOCATION: COSTS, BENEFITS, TIMING AND PROCEDURE

Village planning carried out to ensure equitable distribution of mbuga land would, as explained, cause substantial reduction in village rice production, at least in the short to medium term. However, the keenness of the farmers to start or expand rice growing has been increasing, particularly during the last decade. If this continues, or indeed gathers momentum, most of the short-term losses arising from equitable distribution of mbuga land would be reversed in the long term.

The simultaneous achievement of the most socially fair land distribution and the maximum level of production, though extremely desirable, is often difficult. To some extent these objectives clash, and when faced with this dilemma a trade-off has to be made. Whatever the balance struck, it should not be rigidly laid down with no allowance for future modifications to accommodate rapidly changing circumstances.

Since rice production makes a significant contribution towards the total village agricultural production, it should be included when assessing the village food security and economic viability. At the early stages of village planning the importance of rice to the planned gross incomes of the individual families should be played down, particularly in the southern and western districts where large areas of potential rice lands lie idle. Rice growing should be encouraged and no restrictions placed on those who want to expand. Equitable allocation of rice land should be undertaken by the planners only when land becomes scarce, and then only if the pattern of distribution is unacceptably skewed.

The expansion of rice cultivation would eventually cause a build up of pressure on mbuga land. Even when there is real pressure the existing traditional tenurial arrangements, which the government appears to condone at least at village level, are often sufficient to cope. Intervention by village elders to allocate or distribute portions of land held by large farmers to the landless is generally effective and any future government efforts in this direction should be aimed at further strengthening of these tenets.

An illustration of how this informal system can work is provided by Simbo Village where rice cultivation began only a couple of decades ago with the arrival of a few large-scale rice growers. Others in the village followed their example until virtually all the land in the mbuga was developed under rice. As the number of farmers who previously planted only upland crops but now wanted to cultivate rice grew, large proportions (up to two thirds) of hitherto large holdings were fragmented and redistributed by the village elders without any government intervention. By this process, more equitable land distribution was achieved when it really mattered (i.e. as and when the pressure on land developed), but with no interim loss to the overall village rice production.

ASSESSMENT OF VILLAGE RICE GROWING POTENTIAL SUBJECT TO WATER AVAILABILITY

When assessing the potential of a village to grow rice the availability of water is only one of the factors that need to be considered. In many villages, for example in those of Urambo District, the farmers' preference for using their labour resources for ventures other than rice growing is much more of a constraint to increased rice production than is the non-availability of water. In planning such villages therefore, accurate assessment of water availability for growing rice is not warranted. In contrast, in many villages of Nzega District, the binding constraint might very well be water, if not mbuga land itself.

Although the terms of reference are rather broad, the main focus of this consultancy is on water resources. A simple methodology, based exclusively on the availability of supplementary water resources in the village, was developed to assess the amount of village mbuga land that could be cultivated under rice. Where water is not the binding constraint, the potential thus determined will be an overestimate.

The methodology is explained in detail in Appendix 2. Towards the end of the consultancy, a seminar on rice growing, concentrating especially on the water regime aspects of flood rice, was held. Among the participants were the members of the village planning teams and the opportunity was taken to explain how the methodology can be applied in practice. During the field visits three counterpart staff were also provided with training at field level on how to apply the methodology.

When applied to the village as a whole, the methodology will help the planners to get an idea of how much land, located in which part of the mbuga can be irrigated with the village water resources. This methodology is based on greatly simplified hydrologic principles and the results it produces must be interpreted and used in the same context. The recommended values for the various hydrologic parameters to be used in the calculations are for guidance only and they may be modified as and when field measurements become available. The methodology itself need not be modified because the accuracy of its results is considered to be compatible with the general level of accuracy at which the village planning is likely to be undertaken. Furthermore, if a hydrologically more sophisticated and hence mathematically more demanding methodology were to be attempted, the planning teams might lack the expertise to use it.

References

ACRES, B. D. (1980) *Background information on water control for rice cultivation in Tabora Region, Tanzania.* Land Resources Development Centre, Tolworth. (Unpublished)

ANON. (1978) *Notes on Tabora Regional Integrated Development Programme seminar.* Nzega, Tanzania. (Unpublished)

BROKONSULT A. B. (1980) *Tabora Region water master plan.* Final report. Brokonsult, Sweden.

CHINGANGA, H. M. (1984) *Rice in Tanzania.* Paper presented at the International Rice Workshop at Lusaka, Zambia, 9-19 April 1984. International Rice Research Institute, Philippines.

MANSFIELD, J. E. (1982) *Agronomic aspects of the Tabora Region of Tanzania.* Land Resources Development Centre, Tolworth. (Unpublished)

MINISTRY OF AGRICULTURE, ZIMBABWE (1982) *A regional inventory of agricultural resource base, Volume 3.* Country report. Southern African Development Co-ordination Conference.

MITCHELL, A. J. B. ed. (1984) *Land evaluation and land use planning in Tabora Region, Tanzania.* Land Resource Study No. 35. Land Resources Development Centre, Tolworth.

MOONEN, M. A. (1986) *Possibilities for water control on small-holder irrigated rice.* L. H. Wageningen, Netherlands. (Unpublished)

MOORMANN, R. and VAN BREEMEN, N. (1978) *Rice: soil, water, land.* International Rice Research Institute, Philippines.

MREMA, G. C. (1984) *Development of small-holder irrigation in Tanzania: problems and prospects.* Paper presented at the African Regional Symposium on small-holder irrigation at Harare, Zimbabwe, 5-7 September. Hydraulic Research Ltd, Wallingford, UK.

PATEL, B. N. and CHARUGAMBA, B. S. (1981) *Progress report on varietal and fertilizer demonstration.* Tabora Region Integrated Development Programme, Crop Component, Tabora, Tanzania. (Unpublished)

SILVA, G. L. (1987) *Rice irrigation consultancy field report, March – May 1987, Tabora Land Use Planning Project, Tanzania.* Land Resources Development Centre, Tolworth. (Unpublished)

WILY, L. (1987) *Collected notes on the socio-economy of rice production in Tabora District.* (Unpublished)

Appendices

APPENDIX 1: FURTHER NOTES ON LAND TENURE

Fundamental principles governing land tenure in the region have arisen from those of 'usufruct'. All land belongs to the state and individuals have no rights to own land but are entitled to as much as they care to use (including fallow). Such land may be obtained free and the farmer concerned has the controlling rights as long as the land is being 'used' by him. Rights to use a piece of land can be transferred, but cannot be sold.

The amount of land a farmer (household) can cultivate by hand is small, and as long as the population was low, the supply exceeded the demand and farmers could cultivate as much land as they wanted. However, population increase, villagization and oxen cultivation, have created a land shortage in recent years, particularly in the northern districts. Most of the upland land is now 'owned' and a new farmer can secure rights to a portion of such land mostly by way of a negotiated transfer, usually from a member of his family.

In many senses the situation concerning the mbuga land is different. In the long history of dry-land cultivation in the region, low-lying mbuga land has always been regarded as wasteland and except perhaps for some dry-season grazing, mbuga land has not been much used. Under usufruct, these unused lands should be freely available for anyone intending to use them, say for rice cultivation. In almost all the villages visited during this consultancy, it was revealed that all mbuga land is 'owned' (according to the principles governing usufruct) by individuals whether it is being cultivated or not*. In some cases the areas claimed to be owned by these individuals (or families) are very large.

Two examples of such holdings are as follows:

(a) Mr Mwanakalili and his two brothers of Tambalale Village (Igunga District) own 109 ha of mbuga land and 53 ha of upland. In 1987 2 ha of mbuga (rice) and 17.5 ha of upland were cultivated. Mr Mwanakalili is a recent arrival in the village and claims that his friend, a local inhabitant, gave him all this land. Subsequently he has persuaded his brothers to join him. The brothers have been in the village for the last four years but have not yet started rice cultivation. The family holds large cattle herds and belongs to the Wasukuma Tribe.

(b) The grandson of the former chief of Bulunde Village (Nzega District) belongs to the Nyamwezi Tribe and owns >60 ha of mbuga land. No rice is cultivated yet but he is said to be waiting for a bulldozer to arrive to clear the land.

While some individuals 'own' large areas of mbuga land, there are many who do not have access to any mbuga land, even in their own villages. Mostly this is because they are not yet interested in growing rice.

Although it is said to be impossible or illegal to sell, rights to cultivate land or 'land' itself are being transferred on various pretexts among individuals for

*Land tenure based on usufruct and its specific practice in two villages in Tabora District are described in Wily (1987). The situation pertaining to mbuga land reported therein differs to some extent from that described in more general terms in this report.

payments in cash and or in kind. Such transactions seem to be more common between those who own large areas of land (by implication, those who have more land than they can cultivate) and the new arrivals to the village who do not have preferential rights to own village land. A farmer interviewed during a visit to Bulunde Village said that he arrived in the village in 1983 and obtained 0.8 ha (2 ac) of bunded mbuga land in exchange for a calf, valued at that time at Tsh 1500. He claimed the going rate in the village in 1987 was between Tsh 2500 and Tsh 10,000 per ha, the latter for land nearer the village and the main roads. He was currently negotiating to buy further 0.8 ha. In Chamwabo Village (Nzega District) where about a quarter of the farmers are landless, the going rate for renting land (upland) was said to be up to about Tsh 2500 per ha per annum. In Simbo Village (Igunga District), large extents of virgin mbuga land had changed hands at Tsh 125/ha some 10 years ago.

It is often claimed that these payments are not for the land itself but for the land improvements the previous owner had undertaken. If so, the transactions may be regarded as legal in the context of land tenure based on usufruct but what amounts to 'land improvements' and what they cost still remain debatable. In the case of Bulunde Village the sensitivity of price to proximity to main roads suggests that the land value is not entirely the value added in the form of land improvements.

Negotiations between buyers and sellers take place so secretively that the terms and conditions of the transaction are hardly known to others. Irrespective of what the terms are, once the land or cultivation rights are transferred by mutual consent, the rest of the village, including the village elders, accept and respect the transfer. The village government by not taking any action to negate these transactions, either because the law is not tight enough and evidence is hard to come by and/or to avoid confronting village customs and traditions, appears to endorse such agreements.

In those villages where cattle-owning immigrants are settling down, large areas of mbuga land are changing hands. Although not often debated openly, resentment among those who have found it difficult to compete with the newcomers in acquiring a piece of good rice-growing mbuga land was felt during an interview with a group of farmers carried out in Uyogo Village, Urambo District.

A villager usually acquires a piece of village land not by buying it but through allocation by the village elders. In many villages there are extensive areas of idle mbuga land and the total area far exceeds the potential village demand for rice cultivation. Even though all this land is claimed to be 'owned' by individuals, it is not usually difficult to a keen village farmer to secure a piece for rice cultivation but he still has to negotiate with the owner. The owner may demand some favour or other in exchange for land and if money is part of the compensation sought it is usually no more than a token. The actual nature and amount of compensation is said to depend much on the relationship or friendship between the two parties.

It is difficult indeed to see how these friendly transactions differ in principle from those based on a buying and selling arrangement. The former nevertheless seem to attract total respect and acceptance from the village community. The difference may lie in the fact that in the latter case, the 'buyer' is usually an outsider, and the negotiations are carried out on a strict commercial basis. In the other case, the parties concerned are usually fellow villagers (if not relations) and the negotiations are carried out in a community spirit and with a sense of obligation. In contrast to buying and selling, these transactions are often carried out in the open.

If the friendly negotiations with the land owner(s) prove to be difficult, the matter may be brought to the village elders. They will intervene on behalf of the landless villager to secure a piece of land for his use, but still through negotiations. Their plea might be based on the fact that the land in question is not cultivated or used and should therefore be released or, if it is cultivated, the elders can argue that it exceeds the owner's reasonable requirement and should be released for the benefit of the landless to maintain fair distribution. An example of redistribution of cultivated land is provided by Simbo Village where some 20 years ago hardly any rice was grown. An immigrant to the village pioneered extensive rice growing with work animals and the village elders then allocated him some 50 ha of mbuga land. Subsequently, with an increasing interest in rice growing and a rising demand for mbuga land by the villagers, it became necessary to take away nearly two thirds of this land, by now cultivated, and redistribute it among the new rice farmers.

The decisions of the village elders are well respected by the villagers, and are rarely, if ever, challenged. Social isolation appears to be the main deterrent for anyone attempting to defy such decisions. Disputes which cannot be settled at this level can in theory be taken to the village government level. The government, unlike the villagers, does not respect the individual's claim to own land, particularly uncultivated or unused land, and has powers to allocate land for those who need it for cultivation. In general, neither the land owners, nor the landless, would seek assistance from the village government to settle their land disputes. However, a rare case where this had recently happened was noted during a visit to Sungwizi Village.

APPENDIX 2: A METHODOLOGY TO BE USED BY VILLAGE PLANNERS TO ASSESS THE POSSIBLE RICE GROWING AREA SUBJECT TO WATER AVAILABILITY

Demand for water

The area of rice that can be cultivated in a given village obviously depends, among other things, on the *timely* availability of water to satisfy the crop water demand; it may be defined as follows:

Timely water demand = Timely crop water requirements + Field losses.

This equation is time dependent and therefore the calculations have to be based on discrete time intervals. It is recommended that half-month intervals be used. If half-monthly rainfall statistics are not available monthly intervals may be used. It should be borne in mind, however, that if the crop is subjected to water stress for periods longer than say 10 days, the rice yields will suffer. Under favourable soil conditions (e.g. soils over-lying hardpan with good soil moisture characteristics), favourable rainfall regimes (i.e. well distributed rain over the time interval) and good field water control conditions (i.e. storage of adequate amounts of water in the field using bunds and proper regulation of inflow/outflow), the adoption of a one-monthly time interval may not cause serious errors.

The crop water requirement at a given time (or during a certain period, say half a month) depends on the prevailing climate. It is a function of (a) climatic factors such as wind speed, relative humidity, temperature, sunshine hours etc., (b) a crop factor (in this case that of rice) and (c) the stage of crop growth.

Within the region as a whole, the variation in the crop water requirement from one location to another is insufficient to warrant separate calculations for each location. The calculation is somewhat complicated and moreover the required climatic data are available only at one or two locations. To simplify matters, it is recommended that the following half-monthly figures be adopted during the rice growing season throughout the region.

Half-monthly crop water requirements (mm)

Nov		Dec		Jan		Feb		Mar		Apr		May
110	100	100	100	90	90	90	80	80	90	90	90	90

Field losses are primarily sub-surface deep percolation plus any loss that takes place through leaky bunds. The latter, though a loss to the particular farmer through whose bunds the water leaks, is nevertheless a gain to the next farmer who cultivates immediately below the first. From the village point of view therefore, the losses through leaky bunds need not be taken into consideration, unless there is evidence to suggest excessive uncontrolled losses, which are unlikely to occur.

On the other hand sub-surface deep percolation can be significant. The loss of valuable field-stored water in this way, particularly during the intermittent dry spells, could be disastrous. The percolation rate depends very much on the permeability of the soil but in the case of rice fields, it is strongly influenced by the sub-surface hardpan invariably formed under the rice cultivation. Such a hardpan need not necessarily resemble that generally described by the soil surveyor: in the context of hydrology, a hardpan refers to a barrier to infiltration, irrespective of how hard physically it is to drill an auger hole through it or how it is formed.

In general, the rice growing soils in the region are sandy clays, the hydraulic conductivity of which may be high, but at shallow depths (<50-80 cm) a compacted heavier sandy-clay layer highly impervious to water can be found. This is particularly so in the mbuga soils. In such cases, continuous deep percolation under ponded conditions is unlikely to be >1 mm/day and this may be neglected since generous allowances were made on the supply side of the water balance equation. If percolation is suspected to exceed 1 mm/day, the half-monthly percolation rate needs to be determined using ring infiltrometers or any other suitable method and this needs to be added to the half-monthly crop water requirement figures to determine total water demand.

The deep percolation loss in general is high in lighter soils with no apparent hardpan but if the groundwater level is high, the net percolation loss may again be insignificant. So there is a danger in attempting to assess this loss merely on the basis of soil texture without considering what lies below. If in doubt field measurements should be taken.

Supply of water

Water supply sources are effective rain, surface runoff, seepage/groundwater and stream flows.

Effective rain

Effective rain is that part which is available to meet the crop water demand having accounted for runoff and evaporation. Such losses are extremely dynamic in nature and depend on the conditions (such as soil moisture status) antecedent to rainfall, and on the distribution, intensity and duration of rainfall, surface runoff characteristics, soil permeability, and the various climatic factors which determine the evaporation rate. In hydrologic models, it is customary to lump these factors into a single factor and express the effective rain as a percentage of the total rain measured over a specific period of time. It is recommended that a factor of 50% be used for the half-monthly mean rainfall and perhaps 10% less (i.e. 45%) for the monthly mean rainfall.

In the design of agricultural schemes it is often the practice not to consider the mean rainfall (i.e. 50% probable rainfall or the amount expected to be exceeded or equalled in say five years out of 10) but the 80% probable value; this increases the reliability of the figure for available rain. Instead of carrying out rigorous statistical analysis with the few available but perhaps unreliable data, it is recommended that 65% and 75% of the mean be taken for the half-monthly and monthly rainfalls respectively to allow for their greater reliability compared with mean rainfall.

All in all, to obtain the design value for the effective and 80% reliable rainfall for growing rice in the region, take a third (approximately 0.5×0.65 or 0.45×0.75) of the local half-monthly or monthly mean rainfall.

It will be obvious that throughout the rice growing period, the total demand far exceeds the calculated available rain for the districts in the region and for this reason, rainfed rice cannot be cultivated at a reasonable level of risk acceptance. Hence the need to look for supplementary source(s) of water.

Overland flow or surface runoff

This can be considered under two categories: the flow derived from the upstream mbuga land and its catchment arriving at the village mbuga as longitudinal flow; and the flow derived from the upland and its slopes in the immediate vicinity of the village mbuga which enters the potential rice growing areas laterally.

The first step is to determine (see below for details) how much of each category of land is available to harvest rain-water runoff, having accounted for those waters already used for crop growing, evaporation and so on. To calculate the amount (volume) of runoff available from the above areas use is made of the following 'indicative' runoff coefficients depending on the runoff-producing characteristics of the water-harvesting catchment.

Catchment	Runoff coefficient
Distant mbuga	10-15%
Immediate mbuga	15-25%
Immediate upland	5-15%

If necessary (i.e. in the rare event that the amount of water calculated is not sufficient to meet the anticipated village demand) the above coefficients may be increased by up to 50%, *provided* that there are hydrologic grounds for doing so. Some field measurements of rainfall and the resulting runoff may be attempted to estimate the true runoff coefficients. The runoff coefficient thus calculated for a given storm is in general very different to the one used for the half-monthly case. To obtain optimum values, half-monthly measurements have to be made over a period of time, not less than say several years. This may be difficult given the constraints under which the planning teams are operating. Under such circumstances it is suggested that the assistance of the hydrology branch (Department of Water) be sought.

The 'effective' catchment area for a mbuga may be less than the gross area shown on a map prepared from aerial photos. The ease with which water can be harvested very much depends on the micro topography and on the established and ever-changing gully and rill drainage patterns. During village surveys care has to be taken to identify such drainage paths (including cattle tracks which often act as gullies) and to determine their micro catchment drainage and runoff-producing characteristics (e.g. soil permeability, rock outcrops and depths to relatively impermeable hardpan, land use etc.) before attempting to assess the potential drainage area. Only the parts with favourable runoff-producing characteristics should be taken as the potential areas from which runoff to grow rice can be realistically expected.

This potential area multiplied by the indicative runoff coefficient (or the realistically modified coefficient) and by the half-monthly rainfall will yield the volume of runoff water available to grow rice subject to losses during conveyance. This calculation needs to be done only for the most critical half-monthly period, during which the water deficit (i.e. the total water demand less the effective design rainfall) is at its maximum. In this calculation, any carry over storage between half-monthly periods has been ignored and this builds in an additional safety margin to the potential rice area thus calculated.

It may also be worthwhile monitoring the number of farmers who systematically harness runoff water (say by building small bunds to tap and divert the flow running down the gullies and cattle tracks) in contrast to those who simply accept whatever they get from the natural system. Availability of water is one thing and its use is another.

Sub-surface water

This can also be considered under two categories: shallow groundwater in the middle of mbugas and interflow (seepage) emerging on the upland slopes.

Interflow on the upland slopes. The amount of water from this source is extremely difficult to estimate without laborious field measurements and rigorous water balance calculations. Any results obtained will be extremely site-specific and within the context of village planning such studies will be difficult to undertake. It is best to be guided by the farmers who cultivate in such zones, determining from them how successfully they grow rice or how often their crops fail due to water shortage. Then from visual observations during the growing season it is possible to determine qualitatively the amount of surplus not used by the farmers to cultivate lands both along the seepage line and down-slope from already cultivated fields. During the drier spells and at the end of the rainy season the soil moisture status and the rate at which the water table recedes can be examined using auger holes. Estimate of the possible expansion area should be conservative.

Shallow groundwater zones. One can work more confidently with these areas than with interflow on upland slopes but the same principles apply. A particular shallow water zone in a mbuga can be demarcated relatively easily by studying the depth to water table using auger holes. An assessment of how reliably rice can be grown in these locations however, can only be made by interviews with farmers because the fluctuations of groundwater level with time is unknown in the absence of long-term records.

Stream and gully flows

Gully flows are derived from overland flows; they are intermittent and their duration is determined largely by the characteristics of the individual storms. Gullies will have their own catchments. Gully flows can be estimated from the overland flow entering the gully. Procedures recommended for estimating overland flow can be used but to take account of increased efficiency of conveyance, the suggested runoff coefficients can be increased by about 50%. Gullies may be natural or may take the form of artificial channels specially designed and constructed to improve water harvesting and efficiency of conveyance.

In contrast, stream flows are of much longer duration, sometimes perennial. Their base flows (i.e. the flow continuously occurring some time after the immediate effect of the storm has passed) are very much derived from sub-surface water resources and would be an extremely valuable source of irrigation. The availability of such flows, in terms of both quantity and timeliness, is difficult to determine by simple hydrological methods, but the scope for their use may be assessed by methods similar to those suggested for sub-surface water resources. Flood flows in these streams are assessed in the same way as gully flows except that account has to be taken of the upstream users, because of them, runoff derived from the entire up-stream catchment will not be available for use. Furthermore, downstream riparian users may also have some claim on the upstream derived flows.

If the flow in the stream is substantial and reliable, there may be merit in developing this resource on a more sophisticated basis than that allowed by indigenous water development techniques. In this case, the services of the regional hydrologist should be sought.

Time imbalances in water supply and demand

Crop demand for water is more or less uniform over time but the supply is usually irregular. This time imbalance has to be bridged by storage regulation. In the case of rice two storage systems can be utilized: standing water in the bunded fields and, particularly where this is absent, soil moisture.

Since rice can thrive on waterlogged soils, water can be stored not only in the soil but also on the surface. The standing water in the bunded rice fields is a valuable store of water, particularly when the frequency of recharge is erratic. The amount of water that needs to be stored in the field obviously depends on the demand, and the amount and frequency of the supply that can reasonably be expected within the half-monthly or monthly time period used in the calculations.

As drought spells two weeks or longer are common it is suggested that the water storage system (bunded fields) should be designed to enable the crop to survive on standing water storage exclusively for at least the half-monthly time interval*. Assuming that the total demand is say 10 mm/day (having allowed for some field losses), the standing water storage necessary to provide for a two-week drought will be about 150 mm. So, at the beginning of this period, 150 mm of water has to be supplied by effective rainfall and other sources, and has to be stored in the field. In practice this means that whenever water is available the standing water storage in the field should be topped up to at least the 150 mm level. If monthly time intervals are used in the calculations about 200 mm of water should be stored.

If the rice crop can be supplied with water in this way, it will not suffer from water stress. The challenge is to calculate how much water is available and when, and based upon that knowledge to calculate how much rice land can be cultivated.

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*The shortage requirement calculation is based on the premise that the crop would rely exclusively on surface storage for periods of two weeks (or more) and completely ignores soil moisture availability. It is acknowledged that the safety margin thus built into the calculations is large, but it is justified on the following grounds:

(a) rainfall information likely to be available for use in the calculations is lacking in quantity and of doubtful reliability. The statistics are unlikely to reveal the real risk of the occurrence of long-duration drought spells;

(b) allowances have to be made for the great variation in the farmers' ability to control water;

(c) seepage losses in some rice plots could be significantly more than those allowed in the calculations;

(d) given the limited availability of expertise in rice growing and irrigation among the planning teams a cautious approach is advocated;

(e) village planning is likely to be undertaken on a rather approximate and aggregate basis, concentrating on large parcels of land rather than paying detailed attention to the physical characteristics of individual plots and under such circumstances higher than usual safety margins are warranted;

(f) in many villages where water is not the main constraint to growing rice, it is not necessary to fine away the calculations of irrigation water requirements.

APPENDIX 3: AN OUTLINE PROPOSAL FOR TECHNICAL ASSISTANCE FOR EXPANSION OF RICE PRODUCTION IN TABORA REGION

Objective

The objective of the proposed technical assistance is to promote increased rice production for the purposes of:

- enhancing national output in order to cut down imports and finally establish an export base;
- increasing village rice production so that the village units become economically viable and secure in their food needs;
- encouraging a wider farming population to incorporate rice cultivation into their cropping patterns to sustain family food needs and then produce for surplus.

Rationale

At present Tanzania imports up to about 25% of its current consumption of rice. Consumption levels are likely to rise more rapidly than the rate of population increase because consumer taste preferences are changing from traditional grain to rice. The country has vast land and water resources suitable for growing rice, and the prospects for exporting rice to the neighbouring countries are good. It is official GOT policy therefore to emphasize rice production.

Approximately one third (2.3 million ha) of the total area of Tabora Region consists of mguba, much of which is potentially suitable for rice cultivation. At present, rice is grown continuously only on about 50,000 ha.

There are several constraints to increased rice production, alleviation of some needing macro level action including policy changes. The most binding in the Tabora Region are water, labour and agronomic constraints, which to a large extent can be alleviated at local (regional) level through the provision of appropriate, comprehensive and sustained technical assistance to the farmers. GOT at present has no resources or formal plans to provide these services, particularly on a regional scale as advocated here. Yet for many over-populated villages in this region, increased rice production is the only hope to secure food self-sufficiency and remain economically viable. In other villages, increased rice production provides a great opportunity for them to participate in and benefit from the growing cash economy and thereby rapidly increase their living standards. Development on this scale can also be accommodated within the village planning procedures which are being applied to the ODA-assisted Land Use Planning Project (LUPP).

Strategy

The relative extent to which the three main constraints (water, labour and agronomic constraints) limit increase in rice production varies considerably among the villages and districts in the region. For any attempt aimed at increasing rice production to have a regional impact, all three constraints have to be tackled simultaneously.

Provision of technical assistance in water development to villages already growing rice extensively (say in Nzega District) will only marginally increase the village rice production. In the absence of agronomic assistance this marginal increase will be only a tiny fraction of the levels that could be expected in other circumstances.

Similarly, developing water resources in those villages which are already relatively rich in water (i.e. those in the southern and western parts of the region), but whose farmers in general are not keen to grow rice will not, on its own, produce any significant results.

In most of the villages in the region, development of human resources in connection with rice agronomy and enhanced use of work animals to relieve labour shortage is perhaps more important than water resource development *per se*. If significant increases in rice production were to be achieved throughout the region, appropriate human resource development would have to be undertaken as well.

A fairly well defined technical co-operation programme to develop water resources is outlined below. On agronomic and work animal aspects some suggestions only are presented as this consultancy gave less consideration to these aspects. Further preliminary work, carried out by subject specialists, may be necessary before drafting a more specific programme of technical assistance on these latter aspects.

Given the large area of the region (some 73,500 km^2), an external technical assistance programme that can realistically be expected to make an impact on the region as a whole in a relatively short time must be based on simple procedures; there should be good prospects for easy replication of project activities throughout the region. The training provided and the technology advocated must be capable of spreading naturally and easily through the many villages in the region. The technology should be low-cost as well as simple, and the bulk of the resources necessary must be mobilizable within the villages. Conditions in Tabora Region lend themselves to development based on low-cost technology, on a self-help basis, with a minimal requirement for external capital inputs.

Work programmes

Water resources development

A three-phase programme to be undertaken in collaboration with the regional irrigation department is proposed. Phase I would essentially be a pilot programme designed to develop technologies to harness water from various types of supplementary sources. Appropriate technologies, as outlined in this consultancy report, to improve the currently employed methodologies would be tested. Using bench-mark comparisons their effectiveness would be evaluated. Training materials and guidelines on the development of supplementary water sources would be produced. A two to three-year period, encompassing a minimum of two full rainy seasons would be necessary for this phase.

During Phase II, a selected number of villages and water sources would be developed, primarily, to field test and modify (as and when necessary) the training and guidelines materials produced in Phase I. To the extent that time and resources permit, new techniques would also be developed and tested. Detailed procedural manuals would be produced on how to implement the next phase. Phase II would last one year with a minimum of one full rainy season.

Phase III is basically the extension phase, during which the proven technology would be disseminated throughout the region. This would be an open ended phase, and external assistance is recommended for at least two years in the first instance.

The specific activities undertaken under the water resource development programme would be:

- selection of a number of representative sites suitable for rice production, each depending on a different type of water source;

- assessment of water resources at each site using appropriate instrumentation (e.g. rain-gauges, flow meters), determining simple hydrological parameters such as depth and duration of rainfall, runoff coefficients, and seepage rates;
- development of each of the selected sites on a pilot basis using the technology most appropriate to the particular water source (e.g. water harvesting, intercepting surface runoff/interflow);
- carrying out of bench-mark surveys of similar sites where farmers are using indigenous water control techniques and comparison of performance with that on the pilot sites;
- preparation of simple guidelines on how to locate suitable rice growing areas and sources of supplementary water and develop these areas for rice production;
- training of counterpart staff and village artisans, leaders and farmers in water resources development;
- planning of Phase III and preparation of procedural manuals;
- assisting in the establishment of a low-cost rice irrigation unit within the regional department of irrigation to continue with the programme.

Rice agronomy

The work programme could be planned, initially for three years. During the first year, a detailed study could be undertaken to determine the various agronomic and socio-economic facets of rice growing in the region. Improved but feasible rice-farming practices, simple enough for the farmers to incorporate into their overall cultivation practices, would be identified. A realistic programme to disseminate appropriate extension messages through the existing institutional framework would then be prepared.

During the next two years, the extension programme could be implemented. This could involve, among other things, motivating and training of farmers to grow rice, undertaking demonstrations and training of extension staff. At this stage external assistance for institutional strengthening might also be considered.

Alleviation of labour constraints

The most appropriate manner by which labour constraints could be alleviated is by facilitating the enhanced use of work animals, principally oxen. Work undertaken could include:

- breeding, husbandry and training of work animals;
- encouraging livestock keepers to maintain larger stocks of work animals;
- training farmers and owners of work animals in the appropriate use of work animals for agricultural activities (and perhaps also for transport and haulage activities);
- design of animal-powered agricultural implements and making arrangements for their local manufacture and easy availability.

The most appropriate technical assistance would be the provision of a series of short-term consultancies but with an established base organization located in the project area capable of carrying out the necessary field work and follow-up as prescribed by the consultants.

To a limited extent, some of these activities could be incorporated into the rice agronomy programme. If this is not possible or inadequate, long-term technical co-operation support might become necessary.

Ancillary technical support

The broad nature of the subject matter covered in each component of the proposed technical assistance means that the long-term technical co-operation staff assigned to this work should have broad expertise. Their work will need to be supplemented by short-term inputs by specialists. Furthermore, the implications of socio-economic and public health aspects within the proposed programme would justify some short-term consultancy inputs on such matters.

Staff inputs and indicative costs

Water resource development component

- One irrigation/water resources engineer for five years
- Specialist short-term consultancies, total one year

Indicative cost (at 1987 prices) £500,000 spread over five years

Agronomy and animal draught-power component

- One rice agriculturist for three years
- One animal draught specialist (or equivalent short-term consultancies) for one year
- Specialist short-term consultancies, total one year

Indicative cost (at 1987 prices) £400,000 spread over three years

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