3. POTENTIAL AGRICULTURAL DEVELOPMENT

3.1 LAND CAPABILITY

Soil suitability and/or land capability is considered as one of the major constraints to agricultural development, both in respect to rainfed and irrigated agriculture. For several purposes of the Water Master Plan (hydrological units, erosion hazard, groundwater recharge, irrigation potentials, etc.) a reconnaissance soil survey was carried out for the whole Region.

From the soil map (Drawing PE 5-1) a land capability map (Drawing PE 8-1) was derived, according to the U.S.D.A. Land Capability Classification for upland crops (See Volume IV, section 7) Nevertheless, this land capability map gives also a first indication of the soils which are suited for and/or restricted to irrigated crops.

In addition, the land capability map will serve in conjunction with the analyses of climate and drought (Chapter 2.4. and 2.5.) as the basis for a potential land use map (Chapter 3.9.).

3.2 CROPPING PATTERNS AND CROP NOTES FOR IRRIGATED AND RAINFED AGRICULTURE

3.2.1 Introduction

In this volume a distinction is made between three farming systems in the region, viz.: dry farming, rain-fed farming and irrigated farming. Dry farming is in fact a marginal type of rain-fed farming, and arbitrarily an average annual rainfall of 900 mm has been taken as the upper limit for dry farming and the lower limit for rain-fed farming.

In the dry farming system the choice of crops is limited to drought tolerant and/or very early maturing varieties and a few species of tree crops. In the rain-fed farming system the choice of crops is much wider and includes many tree crops. An early maturing crop can often be grown when total crop failure is the rule in dry farming areas.

In relation to the objectives of the Tanga Water Master Plan, attention will be paid in this chapter primarily to cropping patterns in irrigated agriculture.

In addition, some specific aspects of rain-fed farming in the region, such as cash crops which can be grown on sisal estates, will be discussed.

Some general outlines of dry farming will be presented, in the next chapter. (3.3)

3.2.2 Constraints on Crop Production

3.2.2.1. Rainfall and Climate

Rainfall is the major determinant of which crops can be grown and with what degree of success in the various parts of the region. In comparison with much of Tanzania, Tanga Region receives a reasonable amount of rainfall of good distribution for rain-fed crop production. Climate was described in outline in Section 2.1 of this volume and is further discussed in Volume II. Agricultural drought is analysed in section 2.5 of this volume.

3.2.2.2. Marketing

The marketing of the agricultural production of the region that is surplus to subsistance, drought reserve or local requirements is assessed as a major bottleneck at present. Sisal, which represents about 70% of the total value of marketed production in the region, has its own well defined and relatively efficient marketing channels. The marketing of the remaining crops however, whether sold through co-operatives or parastatals, is generally highly inefficient (Refer TIRDEP, Tanga Regional Development Plan 1975-80, Volume 2 and TWMP, vol. V, Section 7, p. 102-112). This factor partially explains the high proportion of total production which is marketed through unofficial (and thus illegal) channels.

3.2.2.3. Irrigation

Although irrigation in theory should result in a dramatic increase in productivity, the schemes operating at present are in general only marginally more productive than the surrounding rainfed agriculture[1]. There is considerable scope both to improve productivity on the existing schemes and to develop new areas for irrigation.

3.2.2.4. Seeds and Planting Material

Kilimo distributes improved seeds and planting material when it has sufficient funds, and promotes their use when funds are not available. There is still considerable room for improvement however, and further development in this direction should show a very high return.

3.2.2.5. Fertilizer

Despite the presence in Tanga of Tanzania's only fertilizer factory, fertilizer use and distribution comprises a major bottleneck in agricultural production in the region. Smallholders frequently experience difficulty in obtaining small quantities of fertilizer and usage is consequently very low. Prices have also been very high in recent years. The recently announed subsidy and change in distribution methods should improve the situation.

1) The irrigation of vegetables in the Usambaras is an exception.

3.2.2.6. Cultural Practice

Almost all land is still cultivated by hoe and most attempts at oxenisation and mechanisation have not been markedly successful. The area of land cultivated by each family or Ujamaa village is therefore very restricted. It is considered that intensive efforts will be required to promote efficient mechanisation in the region in the long term if major increases in productivity are to be achieved.

3.2.3. Irrigated Agriculture

3.2.3.1. Mkomazi Valley[1]

The limited availability of water for irrigation in the Mkomazi valley imposes certain limitations on the choice of crops. Irrigated rice, with its high water requirement, should, for instance, not be grown on well-drained soils. The high water requirement of this crop, aggravated by seepage and percolation losses, will result in high costs per tonne of grain produced. With half that amount of water about two times as much maize can be produced (hybrids or composite maize varieties grown under irrigation).

The use of irrigated rice should therefore be restricted to the heavy to soils which at present are waterlogged for several months during the rainy season or which are flooded for such a period of time by the river. Proper soil management and drainage as also the use of selected varieties, can increase yields substantially.

The upland crops most suitable for irrigated agriculture under present conditions of the Mkomazi Valley will be the following:

1) For further details and for possibilities under intensive irrigation see also: AHT: Reconnaissance Study of the Lower Mkomazi Valley, Essen 1976

Hybrid maize: Either hybrids or composites from Ilonga (cooperation with the outreach programme of CIMMYT, Mexico) suitable for the lowland (high temperature) conditions of the Mkomazi valley would be feasible. Hybrid or composites which give highest yields without fertilizer applications should be preferred to those with a higher yield potential, but which can express this potential only under high soil fertility conditions. Furrow irrigation and border irrigation will be the most suitable types of irrigation for this crop. The water requirement of maize increases from 5 weeks after sowing onwards and reaches a peak at silking. It decreases sharply 3 - 4 weeks later.

Cotton: This crop can be grown on dry land farms in the lower part of the valley, but requires irrigation in the low rainfall areas in the northwest. Furrow irrigation can be applied. The peak water requirement of the crop is from the beginning of flowering until 1 1/2 - 2 months later. Best varieties for the area will be the UKA varieties from Ukiriguru (Tanzania). Particularly when large areas are planted with cotton, insect pests, always a problem in cotton growing, may become a serious threat to the crop.

Beans and pulses: Temperatures in the Mkomazi valley are in fact too high for an optimal production of beans. Beans are preferred over pulses in the local diet, however. Therefore it is likely that beans will be grown to an appreciable extent on irrigated fields. Furrow irrigation will be the most suitable type of irrigation. Beans need regular water supply throughout their growing period, but their total life period is short: 2 1/2 - 3 months. Pulses, particularly green and black grams, with their short life cycles and relatively high drought tolerance, can be grown shortly after the harvesting of the main crop when still some irrigation water is avaialble for 1 - 1 1/2 month, or can be intersown 2 - 3 weeks before the harvesting of the main crop.

Vegetables: Types of vegetables which can be grown under irrigation in the valley are for example tomatoes, onions peppers, egg plants, okra and cucumbers. Vegetables need moist soils throughout their growing period. Furrow irrigation will generally be the most suitable type of irrigation.

Bananas: This crop can be planted along the irrigation cannals or, when planted in pure stands, on ridges with irrigation furrows in between. The spacing between rows will have to be about 4.5 m and in the rows 3.5 - 4.0 m for tall varieties. For optimum yields a constant supply of moisture is required. However, waterlogging has to be avoided at any time.

Sweet potatoes: This crop can be planted on irrigated fields when insufficient water is available to grow maize or cotton in the dry season. Sweet potato cuttings can be planted on ridges in a period when still sufficient moisutre can be supplied for a rapid early growth of the vines. The crop will have to be treated as an annual crop. Harvesting can take place 5-7 months after planting. Smallholders will usually harvest the tubers piecemeal. Cutting from high yielding early maturing clones from Ukiriguru would be the most suitable plant material.

3.2.3.2. Lower Pangani River Valley [1)]

(1) Vegetables

On the banks of the Pangani river, soil characteristics are more favourable than in the clayey plains further inland. PANGADECO demonstrated on one of these banks that a successful cultivation of vegetables, bananas and pawpaw is possible.

The banks are confined to strips of about 20 - 30 m wide along the river. The digging of ditches in these banks is sufficient to ensure adequate drainage.

Vegetables, bananas and pawpaw can be grown under either rain-fed or irrigated conditions on these banks. High yields will be possible only under irrigated conditons [1)] since the average annual rainfall does not exceed 1.200 mm-The present small vegetable plots of PANGADECO can well be extended along the banks on both sides of the river.

(2) Rice

The relatively flat water-logged clay plains of the valley were initially primarily considered suitable for irrigated rice cultivation. Rice can be grown on these soils, but a few factors will have to be taken into consideration.

a) The type of organic matter in the top soil. This type is likely to yield toxic products such as butyric acid in anaerobic decomposition (flooded rice soils). Such products cause stunted growth of rice roots and an increased susceptibility of the plant to fungus diseases.

---

1) For further details and for possibilities under intensive irrigation see also: AHT: Reconnaissance Study of the Lower Pangani Valley, Essen 1976.

b) The weed problem. When rice is grown on a large scale in this area, the fields are likely to be infested to an increasing extend by e.g. Cyprus spp. An example of this is the rice area in the coastal beld of Kenya. Such weeds will be difficult to control without a very high input of hand labour and/or an intensive use of herbicides.

c) Technical complications. The irrigation system for the irrigated rice cultivation will have to be operated by pumps. The maintenance of the pumps, and particularly repairs in case of a breakdown, will present major problems for the rice farmers and the irrigation authority.

(3) Sugar Cane

The clay soils along the Pangani river, when properly drained, are suitable for sugar cane cultivation, provided the crop can be irrigated whenever this is required.

Sugar cane needs a steady supply of soil moisture through out the year if it is to give maximum yields. The mean annual rainfall in this area (about 1.200 mm) cannot meet this requirement. Sugar cane only yields well under conditions of free drainage. On the heavy soils along the Pangani river it will therefore be necessary to construct an extensive drainage system.

The requirements for sugar cane growing on the Pangani soils can be summarized as follows:

a) A reclamation stage of about 2 years to leach the salt from the soil and to permit a ripening of the soil to a depth of about 1 m,

b) The construction of an extensive drainage system, after the reclamation stage, preferably with drain-pipes

c) The construction of a surface irrigation system. The irrigation water will have to be pumped from the river.

On the soils along the Pangani river it will probably be profitable to harvest up to three ratoon crops after the plant crop.

Apart from soils and ecological conditions, high average yields of sugar cane can be obtained only when a high level of technical management can be applied for both, the sugar cane plantation and the sugar mill. In the lower Pangani river valley this would also include the management and maintenance of the irrigation (and possibly drainage) pumps and the canals.

On the very heavy sticky Pangani soils cane cutting will have to be largely, if not entirely, confined to the dry seasons. At least part of the harvesting work will have to be mechanized to be able to speed up the operation.

The high initial costs for land reclamation, the construction of irrigation and drainage systems, service roads and a sugar mill, will have to be compensated by high average yields of sugar cane. Conditions in the lower Pangani valley will permit such yields.

(a) Yield expectations

On well managed sugar estates average yields of 10-20 t/ha of sugar are common in East Africa under irrigation.

In the Pangani river valley the heavy fertile soils, the availability of sufficient irrigation water, the coastal climate and the relatively high incidence of sunshine, provide favourable conditions for high yielding Barbados varieties. Potential yields under such conditions could reach 25 t/ha of sugar. Based on a full production level of 80% of the cropped area, and actual production of 20 t/ha on 2000 - 3500 ha would imply a total annual production of the order of 30 - 50,000 tons of sugar. It would require the construction of a medium to large sugar mill to process this amount of sugar.

(b) Proposed Pilot Project

A detailed proposal for the reclamation of the clay plains along the lower Pangani river for mechanized or semi-mechanized sugar cane growing, will have to be proceeded by a pilot project of about 100 ha.

The irrigation and part of the drainage system of this pilot project will have to be operated by pumps.

The programme of the pilot project would have to include the following items:

a) trials with different types of soil reclamation,

b) irrigation and drainage trials,

c) trials with different sugar cane varieties and

d) crop management and fertilizer trials.

The design of each of these trials will have to be a simple one (comparison of a few factors only) and should be based on previous experience in East Africa.

In the pilot project experimental data will have to be collected over a period of at least 3 years before definite proposals can be made regarding the establishment of a sugar cane plantation and a sugar mill in the lower Pangani river valley.

3.2.3.3. The Upper Umba River Flood Plain

The upper Umba river flood plain is situated to the north-west of the foothills of the Usambara mountains.

The total gross area of the flood plain potentially suitable for irrigation is estimated at about 2,000 ha. Swamps and marsh reed areas are found in several parts along the river.

The soils of the alluvial plain are fairly heavy dark brown to dark grey clays. The structure of the soil when dry is largely granular. The soils in the slight depressions in the plain (marshy areas) have a heavier texture. Some remain waterlogged during the dry seasons.

The existing irrigation systems, from the tertiary canals onwards, make a rather haphazard impression. The badly levelled fields at the highest elevations of the plain have been used for irrigated rice. Rice growing should have been confined to the lowest-lying fields with the heaviest soils. As a result of poor drainage in the rainy season, these cannot be used for other crops. Maize, cotton, beans and vegetables would do better on the well-drained soils at somewhat higher elevations. The water available in the dry season is at present not used for irrigation.

Much can be improved in respect of irrigation, soil management and crop management.

A pilot and demonstration farm, possibly as part of an aid project, could be established in this area with, for a period of about 5 years, qualified management and personnel will be required for the demonstration and training tasks of this centre.

The following characteristics could apply to the farm:

- it would cover an area of 50 - 60 ha of irrigated land (e.g. 15 ha rice, 15 ha maize, 10 ha cotton, 5 ha vegetables, 5 ha bananas).
- it would have a mechanization unit with equipment for land levelling, ditch construction, etc. and for soil management practices (ploughing, harrowing, sowing, etc.)
- it would have multiplication plots (5-10 ha) to grow seed or propagate plant material of improved varieties for sale to local farmers.

On this farm, the effect of proper land preparation, irrigation techniques, crop management (including double cropping) and the use of improved varieties can be demonstrated during the first 3 years (necessary to gain sufficient experience). After that, it would be possible to train small groups of farmers at the centre and to bring their fields and irrigation systems up to the standard of the farm. After this has been completed for the whole area, the farm may be maintained by either KILIMO or the villages as a farm mechanization unit (see also section 8) and as a centre for the multiplication of seeds and improved plant material for the area.

It would not be difficult to demonstrate on the pilot farm that proper irrigation and crop management techniques, double cropping, as also the use of improved varieties can very substantially increase yields/ha/year, even when no fertilizers are used. This implies that the area can support many more people per unit surface area than at present.

3.2.3.4. The Lwengera Valley

The Lwengera valley is situated between the central and eastern Usambara mountains and covers, downstreams of Magoma village, about 17,000 ha. A large part of the valley is hilly with sisal estates and rain-fed farming. Along the streambeds of the Lwengera river and one of its tributaries (the Nkole river) strips can be found of alluvial soils (heavy dark brown clay soils). Part of these are seasonally or permanently flooded (reed marshes). The major difficulties in this area to develop irrigated agriculture are the heavy soils of the flood plains which require special preparation (narrow beds and deep ditches) to grow crops other than rice and possibly chick peas, the salinity of the soils, and their poor drainage (the soils are highly impermeable).

Provided a substantial increase in the irrigable area in the Lwengera valley is possible (e.g. by constructing a reservoir dam in the Lwengera river in the foothills of the central Usambaras) a pilot project could be proposed in the valley, operating along the same lines and based on the same considerations as mentioned earlier in section 3.2.3.3.

In the Lwengera valley such a pilot project (demonstration farm) would have to include a section on rain-fed agriculture. Soil management (including water conservation techniques), crop management and the use of improved varieties of maize, cotton, beans and pulses, but particularly of virus-free plant material (cuttings) of cassava and sweet potatoes, could increase yields of rain-fed crops very substantially in this area.

In case irrigated agriculture could not be extended appreciably in the valley, the pilot project would have to be oriented primarily towards rain-fed agriculture. Such a demonstration/training centre could provide a nucleus for the intensification of agriculture in the valley and hence for a much higher population density in the area.

3.2.3.5. Lower Msangasi Flood Plain

If the irrigation proposals[1] for the lower Msangasi Flood plain put forward in 1963 (east of the railway Korogwe-Dar es Salaam near Mkaruma railway station) are realistic, the cropping pattern considerations of the Mkomazi valley will be roughly applicable to this flood-plain as well. However slight differences in yields and soil management can be expected due to different soil conditions.

1) See section 3.8 , para. E 1 of this Volume and Technical Report No. 20, Section III.

3.2.3.6. Usambara Mountains

Potential suitable land for irrigated agriculture is restricted by land pressure, topography and soil/water conservation priorities. Irrigation should therefore be confined to high yielding and intensive crops, such as vegetables, potatoes, beans and probably some tree crops. Irrigation of row crops (like maize) on the steep slopes should be avoided as much as possible.

3.2.4 Alternative Crops for Sisal

About 60% of Tanzania's sisal is produced in Tanga region. Almost all of it is grown on estates.

The hard sisal fibre can be used to make twine, ropes, sacks or matting. About 80% of the exported sisal is used for agricultural twine. Competitive fibres are synthetics and other hard plant fibres. The outlook for agricultural twines is very gloomy. Although sisal can compete with both types from a price viewpoint, the total market for agricultural twine may well contract.

For this reason, an effort has to be made to find crops which can replace sisal on some or most of the estates. The following considerations seem relevant.

3.2.4.1 Ecology and Soils

Most of Tanga's sisal estates are situated at an altitude below 900 m. The average annual rainfall varies, depending on the area, from about 800 to over 1200 mm. The soils of the estates are generally well-drained and reasonably fertile, though many of the estates do have very poor soils which are most efficiently used by sisal. Fertilizers and manure (sisal waste) have been applied to the soil on several estates.

Very dry years may be observed once in two to four years. The rainfall pattern is fairly erratic in most years.

The number of crops which may replace sisal successfully on the estates is limited by:

- ecological conditions
- soils
- shortage of pesticides and fertilizers
- prospects for agricultural commodities on the world market
- required capital expenditure
- the necessity to write off most of the investment in sisal processing buildings and plant.

There seem to be reasonable prospects for the following crops 1):

3.2.4.2 Sunflower

Sunflowers usually vary in height, according to variety, from about 1.0 to 4.5 m. The plants have strong tap roots and dense surface mats of feeding roots. Sunflowers are very drought-resistant and yield well in climates with an average annual rainfall of about 750 mm. This implies that in higher rainfall areas (1100 - 1200 mm) the crop will even yield well in dry years. The peak sensitivity of the crop to drought is during the 3 - 4 weeks flowering period. Depending on the variety, plants flower after 2 1/2 - 4 months and take a total of 3 1/2 - 6 months to mature.

The crop can be sown with a maize planter at spacings of 0.3 - 0.4 x 0.75 m. East African varieties are tall and ripen unevenly. The oil content of the seeds is 25 - 28%. Some of the new Russian varieties are much shorter, ripen evenly and can be harvested with a combine harvester. The oil content of the seeds is as high as 50%. There is no experience yet of mechanical harvesting in East Africa.

When sunflowers are grown on a large scale on sisal estates, mechanization of crop management will be necessary, particularly in respect of the harvesting operation which should last as short as possible to avoid shattering of seeds and bird damage. Average yields can be expected to be 1.7 t seed/ha. With improved varieties and good crop husbandry it will probably be possible to increase this figure to 2.5 - 2.8 t/ha.

---

1) See also TWMP, Technical Report TR 13

Sunflower can be grown in rotation with maize, pulses, cotton and cassava. Various combinations are possible, such as:

sunflower - maize - sunflower -
sunflower - maize - pulses - sunflower -
sunflower - maize - cotton - sunflower -
sunflower - sunflower - cassava (2 years) - sunflower -
sunflower - cotton - pulses - sunflower - etc.

The most profitable rotation will depend on market outlets and prices. After several years of crop cultivation, cow peas or tropical kudzu can be grown as a green manure.

It will be possible to grow sunflowers profitably on the sisal estates only if there is a vertical integration of the whole production process. This implies that the crop is not only grown on the estate, but also that seeds are stored, and the oil is extracted, graded and transported to the harbour by the estate. This will minimize storage costs (and losses) and transport costs.

The press cakes of sunflower seeds are a valuable livestock feed and can also be exported.

The long term prospects for sunflower oil on the world market are reasonably good. This semi-drying edible oil is now, together with maize oil, the most important raw material for the production of modern "non-cholesterol" types of margarine and cooking oils in Europe and the USA.

3.2.4.3 Cassava

Advantages of cassava are:

(1) its ability to yield well on poor soils,

(2) its ability to remain in the soil for long periods without a reduction in tuber quality,

(3) its drought resistance and,

(4) its resistance to pests.

These favourable characteristics apply much more to moderately late (16 months) and late (24 months) maturing bitter varieties than to sweet varieties (most of which can be harvested in less than a year).

Rainy seasons have to be long enough to allow for satisfactory tuber expansion. High yields can be expected in climates with an average annual rainfall of at least 1000 - 1250 mm. Well-drained deep soils are best suited for cassava.

Cassava is vegetatively propagated by means of stem cuttings. Planting in rows (spacing 0.8 x 1.6 m) along contour lines may enhance water conservation, particularly when the rows are planted on low ridges. The use of virus-free plant material of clones with a high degree of resistance to mosaic virus and bacterial leaf blight is an essential preliminary for high yields. Early growth is slow and weeding is important at that stage. A very low nutrient requirement is characteristic for cassava.

Late maturing bitter varieties can be harvested two years after planting, but may last for several years in the soil without becoming too fibrous. This implies that when twice as much cassava is planted as will be harvested in a particular year, the reserve plantation can be harvested in an extremely dry year. Thus a constant production can be maintained irrespective of the erratic occurrence of very dry years. This is an important advantage of cassava over other crops when a constant supply of the harvested product to a factory is required.

Mechanical harvesting is not practised anywhere in the world yet, but the implements which would be required for this can be constructed in a fairly simple way (Cassava Division, CIAT, Cali, Colombia).

Cassava as an alternative crop to sisal could be grown for two purposes. The first one would be to grow sweet varieties and produce dried chips for export to Europe as a livestock feed (Tanzania already exports this commodity). The second one would be to grow bitter varieties (with all their advantages) and to extract starch from the tubers in a factory on the estate. The starch would have to be shipped to Europe.

The latter possibility will allow for much less storage and transportation costs, less maintenance costs and security of harvests in very dry years. Yet the initial investment (construction of a factory) will be high.

Cassava can be grown in rotation with sunflowers, maize, cotton or pulses. These crops will generally react favourably to soils cropped for two or more years in succession with late maturing cassava varieties. The most profitable rotation will depend on the marketing situation for the commodities concerned.

3.2.4.4 Cotton

Cotton is probably the most dubious of the crops suggested as alternatives for sisal because: (1) there is no experience in East Africa yet with cotton grown on large farms or estates, (2) the varieties grown successfully in East Africa tend to ripen unevenly (and are therefore not very suitable for mechanical harvesting), and (3) it can be expected that when the crops is grown on a large scale in pure stands, insect pests will become a serious problem. An intensive pest control programme would then be necessary. In addition, intensive weed control is required.

Favourable aspects of cotton are its high drought tolerance, its easy adaptation to a wide variety of soils and, probably most important, the favourable outlook on the world market for cotton (lint), cotton seed oil (an edible oil used in the manufacturing of margarine, cooking oil, soap, etc.) and the residual seed cake (which, due to its high protein content, is a valuable livestock feed).

Soil preparation and sowing can be mechanized without difficulty. Sowing in rows at spacings of e.g. 0.9 x 0.3 m is common practice. The early growth of the plants is slow and intensive weeding is necessary. The main water requirement of the crop is in the 3rd, 4th and 5th month after sowing with a peak in the 4th month. Only American upland varieties have been successful in East Africa. Improved varieties have been bred at Ukiriguru in Tanzania (UKA lines).

On most soils in the Tanga Region, cotton will require nitrogen and phosphate application to give high yields. With good husbandry and efficient pest control yields of seed cotton may reach an average of 2 - 2.5 t/ha.

When cotton is grown on a large scale on sisal estates, it will be necessary to find varieties suitable for mechanical harvesting. In addition, a vertical integration of cotton production would be necessary at the estate level (ginning, grading, baling, oil extraction, etc.) to obtain optimal economic returns. Only estates further inland, with a fairly dry climate, would be suitable for cotton. The climate along the coast is too wet during boll ripening.

3.2.4.5 Maize and Legumes in the Rotation

Soils suitable for sunflowers are also suitable for maize and grams. Depending on the market situation, maize can be grown in rotation with sunflower for both, oil and flour production[1]. The advantage of maize is that for mechanized crop husbandry the same equipment can be used as for sunflowers. Only the harvesters will have to be adapted.

The extraction of maize oil and the grinding of maize flour will have to take place at the estates to economize on production costs. The market for maize oil is the same as the one for sunflower oil. For maize flour there is a potential domestic market since Tanzania has to import maize every year. Most of the maize hybrids and composites suitable for the coastal climate mature in 4 - 6 months.

For short (2 1/2 - 3 months) rotations, e.g. during the short rainy season, green and black grams are probably most suitable because of the high drought tolerance of these crops and because of the relatively high prices paid for these pulses on the domestic market. At least for green grams there is also a limited market in Europe.

Drought resistant legumes which can be grown as green manures include cowpeas and tropical kudzu.

3.2.4.6 Proposed Pilot Projects

To investigate crop husbandry techniques for sunflower and cassava, as also for the crops which can be grown in rotation with these two crops, it will be necessary to establish two pilot projects on sisal estates.

The first one will have to concerntrate on the sunflower - maize rotation, perhaps with, in one plot, grams included in the rotation. This will have to be carried one on a 40 - 60 ha scale. If the pilot area is situated in a relatively, an additional trial could be carried out with a cotton - sunflower - maize rotation (25 ha scale).

The second pilot project, preferably in the coastal region, would have to concentrate on the cassava - maize rotation (80 - 100 ha scale).

Data from the pilot projects will have to be available for at least 3 years before definite recommendations can be made.

1) and possibly for the production of high fructose maize syrups

3.3 DRY FARMING

3.3.1 Introduction

The term dry farming is used in this Report for farming conditions in areas with a too low and/or a too erratic annual rainfall pattern for the more reliable rainfed farming systems. An average annual rainfall of 900 mm is taken here as the arbitrary upper limit for dry farming conditions. Dry farming in East Africa is found from sea level up to an altitude of about 2000 m. At still higher altitutudes the rainfall is usually too high.

The ecosystems of dry areas and the factors involved in dry farming, are still very incompletely understood. Research is urgently needed to find methods to increase production under dry farming conditions. Some outlines of the present knowledge on this subject will be presented in the subsequent sections.

3.3.2 Climate

A bimodal annual rainfall distribution with a "long" and a "short" rainy season is common in most dry farming areas of East Africa. During any of these seasons rainfall distribution is often very erratic, may be concentrated in a few heavy showers with long periods of drought in between, or may come too early, too late or not at all.

Any planning of agricultural activities is very difficult under such conditions and much depends on the flexibility, adaptation, of the individual farmer to the rainfall conditions in a particular season.

In the lowlands the shortage of water in the dry farming areas is aggravated by the prevailing high average night temperatures which may increase the transpiration and respiration rates of crop plants. Remarkably low respiration rates under high temperatures have been found in some of the tropical grass species, however.

3.3.3 Water

3.3.3.1 Total Amount Available

Registered rainfall figures over 15 to 20 years may provide a reasonable average of the total amount of water which can be expected to be available in a particular rainy season in a particular area. On the basis of surface run-off, infiltration rates in the soil, water retention capacity of the soil and evapotranspiration, it can either be calculated or established empirically for which crops sufficiend water would be available to complete their life cycle. This is principally the same approach as the one followed in rainfeld agriculture, but the margins of the total amount of available water which will permit successful crop growth, are much more critical in dry farming than in rainfeld farming.

3.3.3.2. Erratic Distribution

The principal hazard of dry farming ist hat the total amount of water which becomes available in a particular season, is only rarely evenly distributed over that period. In addition, the "season" is often a fairly variable period in the year with a markedly fluctuating total rainfall. Effects of shortages of rainfall, as also of prolonged periods of drought between rains, may result in total crop failures. (See Chapt. 2.5. of this Volume).

If the rainfall pattern has been registeres during periods or more, it is possible to calculate the percentage chance, of a crop to complete its life cycle when it is sown after a certain amount of rain has fallen in a certain period. 1) This is as far as prediction on the most suitable sowing dates can go at present. Further improvement awaits accurate waether forecasting techniques over periods of about three months.

3.3.3.3. Moisture Conservation

The retention of rain water in the soil depends on the physical properties of the soil and on soil management. Light soils generally have a poor moisture retention capacity and offer very little potential for dry farming. Soil management techniques can be applied for the following purposes:

- conservation of the moisture present in the soil,
- prevention of surface run-off of rain water,
- promotion of rain water infiltration in the soil,
- utilization of residual moisture in the soil after the cropping season.

---

1) See Technical Report No. 19

The moisture which is present in the soil can be conserved by a thorough tillage of the upper layer of the soil. This layer then dries up and prevents further evaporation of moisture from the deeper soil layers (disruption of soil capillaries). A method based on the same principle is the cultivation of the land during a fallow period, whereby all weeds are ploughed into the soil and a fairly shallow tilled layer of 10-15 cm is formed. The elimination of weeds can be quite important, since these tend to dry out the soil completely before the onset of the following rainy season. This naturally makes the moisture supply during the subsequent cropping season more critical.

Surface run-off may be quite serious, even on only slightly undulating land, when the soil has a low structural stability of the upper horizons and silts up or forms surface crusts when wetted to zero tension. The surface run-off can cause soil erosion. Methods to prevent it are:

(1) certain types of soil management (contour ploughing, contour ridges, terraces),

(2) the use of vegetation (strips of vigorously rooting grasses planted along the contours or on terrace walls, grass or legume cover crops),

(3) mulches of plant material, mainly cut grass (rarely available in sufficient quantities)

(4) stone and/or gravel mulches.

The latter have been used successfully in tree or shrub crop plantations in some countries (e.g. Iran). These mulches can also suppress weed growth satisfactorily.

The infiltration of rain water in the soil is promoted by the same methods as the ones used to prevent run-off. Other methods are: shallow tillage (breaking the surface crust) or adding organic manures (which are hardly ever available) to the top soil layer.

The utilization of residual water in the soil after the cropping season, is usually confined to soil moisture conservation for the following cropping season. Only on heavy soils in fairly flat areas and with a moderate rainfall (700-900 mm/year) it may be possible to raise a crop in the dry season on the residual moisture in the soil. For this purpose broad and deep ditches have to be constructed along the contour lines at about 2 m distances. Furrows are dug on the ridges to secure sufficient penetration of rain water in the soil. During the rainy season, crops are grown on these ridges. Water tends to accumulate in the ditches. At the end of the rainy season, the ditches begin to dry up. Crops are then planted in these ditches and the soil between the plants is superficially tilled to prevent further water losses through evaporation. This second crop, grown in the dry season, is usually planted one to three weeks before the harvest of the first crop. The second crop may consist of early maturing varieties of maize, beans, pulses, cowpeas and sweet potatoes.

The yield of this second crop is usually much lower than that of the first crop, but it is important with regard to a better distributed food supply throughout the year. It diminishes the need for food storage.

3.3.4 Crops

3.3.4.1 Crop Characteristics

Crops suitable for dry farming conditions can either be tolerant to drought or can "escape" drought (by very short maturation periods). Other useful plant characteristics are, in combination with drought tolerance, a flexible harvesting period (e.g. cassava) and a perennial growth habit (e.g. of tree crops).

In most crop plants sensitivity to drought reaches a peak at the flowering and early fruit development stages. The degree of sensitivity varies greatly among different crop species, however. Maize, for instance, is much more sensitive to drought during that stage than millet or sorghum.

Farmers in dry areas normally try to avoid the risk of unexpected periods of drought during the sensitive stage of a particular crop plant by intercropping two, three or even four different species. For example, maize and pumpkin; cotton, maize and grounnuts; cassava, maize, pidgeon peas and beans (or groundnuts, cowpeas). In such combinations each of the species, reaches its peak sensitivity to drought in a different period. Drought during a particular period may then result in the failure of one crop, but would leave the farmer with the yields from the other crops grown in his field.

The intercropping system, in addition, spreads the risk of pests and disease damage.

The combination of different plant species in mixed stands often yields more than the sum of the same number of plants would do when grown in pure stands. The reasons for this probably include differences between plant species in rooting depth, moisture and nutrient extraction capacity, nitrogen fixation (legumes), shading, etc. Such intercropping systems

are generally the best possible production method available to the small farmer under the prevailing conditions (low and unreliable rainfall, few possibilities to control pests and diseases, no fertilizers and low labour productivity).

An important advantage of the intercropping system is that crops are grown together will mature at different periods. The subsequent harvests provide the farmer with a diverse supply of products over longer periods, thereby reducing the need for food storage and maintaining a diversified diet. This in particular because several crops have an "extended" harvesting period. Piece-meal harvesting of young fruits (maize, groundnuts, beans) or tubers (sweet potato) for daily consumption may start a few weeks before the actual harvesting of the mature product. Both factors, the regular supply of products and the diversity of products are usually highly valued by the farmer.

3.3.4.2 Drought Tolerance

The following major crops grown in East Africa are drought tolerant (the lowest average annual rainfall in mm under which these crops can still be grown successfully in certain parts of East Africa, is presented in brackets behind the name of each crop).

- cereal crops : bulrush millet (500 - 600 mm), sorghum (650 mm),
- pulses : green and black grams (650 mm); pigeon peas (650 mm), cowpeas (700 mm),
- oil crops : sesamum (750 mm), sunflower (750 mm), perennial castor (500 - 625 mm)
- fruits : mangoes (650 mm), cashew (700 mm), pumpkin (750 mm), pineapple (850 mm),
- fibre crops : sisal (650 mm), cotton (650 mm).

A flexible harvesting period is particularly pronounced in late maturing bitter cassava varieties which are not ready for harvesting until two years after planting and may last as long as six years in the ground without becoming too fibrous. The crop can thus serve as an important source of "stored" food in the ground during very dry years when other crops fail to produce yields. However, cassava is restricted to lower altitudes (up to about 1500 m) and yields poorly in dry areas. The bitter cassava varieties have, on the other hand, the advantage of being almost completely free of pests (pigs, porcupines, baboons, insects).

A flexible harvesting period is also found, but to a much lesser extent, in sweet potatoes. The smallholder usually harvests the tubers of this crop piecemeal.

Perennial crops, particularly trees, have the advantage that they can extract moisture from much deeper soil layers than annual crops, and that their extensive root systems can even absorb the moisture supplied by a few small showers which may occur in very dry years.

The perennial growth habit of cassava, pidgeon peas, castor and sisal are important in this respect, but an even greater potential is probably offered by the tree crops (cashew, mango) but this remains to be investigated properly. To these tree crops, some species indigenous in semi-arid zones, such as the shea butter tree, can probably be added. But this, again, remains to be investigated.

3.3.4.3 Drought Evasion

Very early maturing (70 - 100 days) crop plants can evade drought by completing their life cycle at the end of very short rainy seasons. Very early maturing varieties are e.g. available of grams, beans and groundnuts (70 - 90 days), bulrush millet, sorghum and maize (85 - 100 days) and sunflowers (100 - 110 days). Some varieties have been bred primarily for dry farming conditions such as some early maturing maize varieties (the Katumani composites) for the Machakos and Kitui Districts in Kenya.

To take as much advantage of the first rains as possible, seeds can be sown in dry soil before the onset of the rains. This is, for instance, practised in the Machakos District with maize. Early sowing is apparently also favourable for maize because of an optimal air: water ratio for root development in the soil after the early rains. In cassava cultivation the maximum use of early rains can be made by planting the cuttings in furrows which accumulate rain water. At later stages, the furrows are levelled and finally ridged to promore tuber formation.

3.3.5 Storage

Storage of harvested products and sowing seed is more important in dry farming than in ordinary rainfed farming systems because of the much greater risks of crop failures in dry as compared to wet climates.

3.3.5.1 Storage of Seeds and Food Grains

When the onset of the early rains is followed by a long dry spell, early crop growth may fail completely. The fields will then have to be resown. This may even happen several times in succession. The stored amount of sowing seed would have to be sufficient to meet such conditions but it rarely does. The farmers are then in the position that they have to use either their own food grain stocks for sowing seed or that they have to try to obtain seeds from outside the region. Perennial crops in this respect have the advantage over annual crops that they have to be sown once in so many years only.

Storage facilities are, contrary to their needs, often poorly developed in dry farming areas. Lack of capital and incentives are usually the main reasons for this. Products such as cassava tubers, which can be harvested whenever needed, are therefore of particular importance. Yet these are usually insufficient to bridge prolonged periods of food shortage in very dry years. Stored food, cereals in particular, would have to be the main basis to overcome such shortages.

3.3.5.2 Food Production and Storage

One of the main difficulties at present is that farmers even if a sufficient storage capacity would be available, would not be able to produce sufficiently to obtain a substantial surplus of agricultural products for storage. The principal constraints to farm productivity are the low average yields per hectare and the limited surface of land a farmer and his family can cultivate. To improve this situation labour productivity (and/or labour input) and crop yield would have to be increased (by using, e.g. improved varieties, improved soil management and water conservation techniques, fertilizers, better pest and disease control, etc).

Of these factors, increases in labour productivity by oxenization or mechanization, and of yields by (chemical) fertilizer applications or by (chemical) control of pests and diseases, would require the highest capital inputs. Improved soil management techniques generally require a high labour input. First priority should therefore be given to the use of improved varieties (bred for drought tolerance, drought evasion, and/or pest and disease resistance).

3.4. AGRICULTURAL ENTERPRISE BUDGETS

3.4.1 Introduction

In order to define the economics of irrigation development in the Region and to give a general indication of the profitability of dryland crop production, the following enterprises are analysed. 1)

Irrigated	Dryland
Beans	Beans
Maize	Maize
Rice	Cotton
Bananas	Sorghum
	Cassava

3.4.2 Value of Production

In order to simplify calculations, product prices are always expressed in cash terms, based on the current parastatal or co-op buying prices. Thus subsistence requirements are valued at sales price while major crop losses after harvest are not taken into account.

The following product prices are applied:

Grade	A Sh/Mt	B Sh/MT	C Sh/MT	Average Sh/MT
Maize	750	500	350	700
Beans (navy)	1750	1350	-	1630
Rive (paddy)	1000	-	-	1000
Cassava (dried)	400	380	-	390
Sorghum	750	-	-	750
Millet	850	-	-	850
Cotton	2000	1000	-	1700
Groundnuts	2000	-	-	2000
Sunflower seeds	1000	-	-	200
Bananas	200	-	-	200

1) More detailed analysis is contained in:
TIRPED: Tanga Integrated Rural Development Plan 1975-80, Volume 3; AHT: Reconnaissance Study of the Lower Mkomazi
Valley: AHT Reconnaissance Study of the Lower Pangani Valley

2) Average free market price at farm gate.

3.4.3 Crop Yields

As outlined in section 2.3, yields throughout the region are very variable, depending on:

- average rainfall, amount and distribution
- rainfall within one cropping season
- drought incidence
- pest and disease incidence
- the managerial ability of the farmer
- soil type
- the availability of irrigation water
- farm and family size
- availability of improved seeds
- quality of the extension service.

Since reliable data on yields in the various areas over a period of years are unavailable, it is necessary to make estimates in each case.

Rainfed/Dryland Crop Yields

a) Low or unreliable rainfall areas

	Yield Potential MT/ha	Present Yield MT/ha	Likely Future Yield 1) MT/ha
Beans	1.0	0.4	0.6
Maize	2.0	0.7	1.3
Cotton	1.0	0.3	0.5
Sorghum 2)	1.8	0.6	1.2
Cassava 2)	2.0	0.8	1.5

b) Areas of adequate rainfall

	Yield Potential MT/ha	Present Yield MT/ha	Likely Future Yield 1) MT/ha
Beans	1.5	0.6	0.9
Maize	3.5	1.0	2.0
Cotton	1.5	0.5	0.7
Sorghum	3.0	0.9	1.7
Cassava	3.0	1.1	2.0

1) 20 year horizon
2) Per annum

c) Irrigated Crop Yields

Without Fertilizer

	Yield Potential MT/ha	Smallholder Present MT/ha	Smallholder Future MT/ha	Irrigation Scheme Future MT/ha
Beans	2.0	0.7	1.1	1.3
Maize	4.5	1.2	2.5	3.5
Rice[1]	4.0	1.8	2.5	3.0
Bananas	25.0	10.0	15.0	20.0

With Fertilizer

Beans	2.5	-	1.3	1.6
Maize	5.5	-	3.5	4.5
Rice	5.0	-	3.5	4.0
Bananas	35.0	-	20.0	30.0

3.4.4 Crop Costs and Gross Margins

The major costs of production are seeds, (which of course often are retained, but still represent a cost), fertilizer, machinery use or hire when applicable and labour. It is debatable whether smallholder labour inputs should be allocated a positive price, but since subsistence output is valued, and also in order to take account of labour constraints, labour is costed here at its approximate shadow price of Sh 3 per day [2]. Irrigation water is not costed.[3]

Crop costs are summarised in the following Table AG 3-1, together with budgeted output and enterprise gross margins (output minus directly attributable costs).

1) Single cropped

2) This price corresponds closely with free market rural labour price.

3) Irrigation water is not charged for at present, while in analysing any future scheme, cost estimates must be made for the specific case.

Table AG 3-1: Crop Costs, output and gross margin

		Output Sh/ha	Costs Sh/ha	Gross Margin Single Cropped Sh/ha	Gross Margin Double Cropped Sh/ha
Irrigated beans	1	1140	470	670	-
	2	1790	600	1190	-
	3	2120	700	1420	2480
	4	2120	660	1460	-
	5	2600	760	1840	3220
Maize	1	840	420	420	-
	2	1750	620	1130	-
	3	2450	960	1490	2610
	4	2450	920	1530	-
	5	3150	1440	1710	3000
Rice	1	1800	590	1210	-
	2	2500	760	1740	-
	3	3000	1060	1940	3400
	4	3500	1100	2400	-
	5	4000	1420	2580	4520
Bananas	1	2000	250	1750	-
	2	3000	420	2580	-
	3	4000	480	3520	-
	4	4000	610	3390	-
	5	5000	860	4140	-

1 Smallholder present, without fertilizer
2 Smallholder 1995, without fertilizer
3 Irrigation scheme, 1995
4 Smallholder 1995, with fertilizer
5 Irrigation scheme, 1995 with fertilizer

The double cropping results refer to 100% double cropping for maize and beans and 75% double cropping for rice (the balance of the land being single cropped).

Table AG 3-1 (contd.)

		Output Sh/ha	Costs*) Sh/ha	Gross Margin Sh/ha
Dryland Low Rainfall				
Beans	1	650	380	270
	2	980	480	500
Maize	1	490	300	190
	2	910	370	540
Cotton	1	510	460	50
	2	850	650	200
Sorghum	1	450	300	150
	2	900	370	530
Cassava	1	310	200	110
	2	590	420	170
Dryland Good Rainfall				
Beans	1	980	450	530
	2	1470	570	900
Maize	1	700	350	350
	2	1400	430	970
Cotton	1	850	540	310
	2	1190	770	420
Sorghum	1	680	350	330
	2	1280	430	850
Cassava	1	430	230	200
	2	780	490	290

1) Smallholder, present
2) Smallholder 1995, partially mechanised
*) Costs for Low Rainfall reduced by 15% to account for years in which full cultivation and planting is not possible.

3.4.5 Discussion

The results of the analysis indicate that:

a) The low rainfall dryland crop enterprises generally show rather low returns, but in general are able to cover their direct costs (which are mainly labour). Cotton and cassava show poor returns, due to low yields and low product prices. Cotton continues to be grown in Tanga Region largely because it has a relatively well organised infrastructure, and is a 100% cash crop, while cassava, despite its low cash value, is a valuable staple and drought reserve food stuff.

b) Under good rainfall conditions, gross margins increase by an average of 50 % compared to low rainfall margins, since costs are directly comparable and output is substantially higher.

c) The irrigated crops analysed all show substantially higher returns than the dryland crops, but it must be remembered that water costs must be deducted before direct comparison is possible.

3.5 LIVESTOCK

3.5.1 Constraints

The major constraints affecting livestock development are outlined below. A number of the factors are examined in more detail in sections 3.5.2 to 3.5.5. below

a) Water

During the wet seasons, water is virtually non-limiting, but after the end of the rains, water becomes progressively scarcer throughout much of the lowland part of the region. This creates severe management problems and in, fact prevents full use being made of many of the regions grazing areas. The development of ground water resources or construction of surface storages is possible in most areas, but it must be remembered that the provision of a limited water supply network can create severe problems of overgrazing in the vicinity of the water points.

b) Pasture Types

Relatively few of the pasture species in the region are very productive, since the periods when they are reasonably nutritious are very limited. Potential liveweight gains per hectare are thus low. Little work has been undertaken in the field of pasture improvement, and much development work will be required before it becomes economic on a large scale.

c) Livestock Performance

The strains of most types of livestock produced in the region are generally unproductive, with poor breeding and weight gain potential. The accelerated introduction of improved stock (or semen) should be given high priority if livestock output is to be improved.

d) Social and Management Problems

The main constraints on smallholder livestock production in Tanga Region are listed below:

- the major objectives of cattle ownership are security, social status and wealth. These objectives are to a large extent imcompatible with economic production. Herd size is maximised at the expense of productivity.
- ownership is often complex.
- grazing areas are communal.
- stocking is uncontrolled.
- there is little or no attempt at systematic disease control.
- water points are widely separated during dry seasons.
- tick and tsetse fly are major problems
- the grazing areas and watering points available to the Masai are being reduced due to the establishment of ranches and ujamaa villages. The cost of well sinking has also risen sharply.
- reproductive performance is poor, calf mortality high and growth rates low.
- the practice of keeping stock in night bomas, which greatly reduces potential rates of weight gain.

e) Ranch Production

Ranches experience many of the same problems especially with disease (Red Water, East Coast Fever, Trypanasomiasis, Foot and Mouth), and are at present unable to achieve economic production. They also incur high labour costs which cannot be offset by intensification. Further research on improved pasture establishment and herd upgrading may allow economic ranch beef production in future.

f) Overstocking

Several areas in Tanga Region show signs of severe overstocking, in particular:

The Mkomazi Valley between the Usambara and Pare Mountains. Grass cover has virtually been eliminated and severe sheet and gully erosion is widespread. This overgrazing appears to be mainly caused by the use of the valley as a stock movement route by nomadic herdsmen.

The Umba Plain - at least along the Mnazi to Tanga road overgrazing is evident.

Chanika Division - Central Chanika, in the Mzeri Hill Ranch area, has historically been overgrazed but is now regenerating due to controlled grazing. The area to the north and west of the ranch however is under severe stress due to the reduction of the grazing area left to the Masai after the establishment of the ranch.

Densely Settled Areas - Many areas of overgrazing are to be found in the vicinity of watering points in densely settled areas. The Western Usambaras in particular appear to be carrying an extremely high number of livestock.

g) Ticks and Tsetse

Ticks are a severe problem for cattle and to a lesser extent goats in most of Tanga Region. They cause direct losses through

- causing East Coast Fever and Red Water with resulting loss of condition or death
- affecting stock health through their physical numbers
- necessitating frequent dipping, weekly or more frequently in the case of the red tick, with loss of productivity and considerable cost of labour and acaricide (anti-tick insecticides).

Many acaricides moreover are losing their efficacy due to the evolution of resistant strains of tick.

It remains possible however to contain tick numbers and prevent major stock losses, but it will be difficult and expensive to attempt a regional control programme.

Tsetse fly cause economic loss due to

- causing physical unrest among the stock
- the transmission of trypanasomiasis which results in lowered growth rates, loss of condition and death in severe cases
- precluding human habitation and/or livestock production in some areas
- the cost of curative and preventative chemicals and associated labour costs.

Tsetse fly are prevalent throughout much of the bush and woodland of Tanga Region. Long term control may be feasible if areas of its habitat can be isolated by clearing and sowing crops or pasture, followed by insecticide application and sterile male release. This approach is being applied by the Tsetse Fly Research Centre in Tanga.

3.5.2 Pasture Improvement

Rangelands

Up to the present, very little pasture improvement has been undertaken, and reliance is largely placed on the native species such as green panic (Panicum maximum), Themeda, Hyparrhenia and Digitaria species. Most native species tend to produce good quality fodder when young but often mature rapidly and have low protein and energy contents during most of the year. In order to support higher stocking intensities than the normally achieved levels of one LU per 2 to 3 hectares, suitable improved species will have to be found and introduced.

Since the technology of bush control and pasture establishment, fertilisation and management is virtually untried in Tanga Region at present it is unlikely that pasture improvement will have any significant impact on the rangelands of the west, north and south of the region within 20 years. It is important however to lay the foundation now for the long term future, and to this end individual ranches and enterprises could be given assistance with field scale varietal evaluation and pasture improvement technology.

Ujamaa and Smallholder Areas

Very few villages have thus far been involved with pasture improvement. Exceptions include guinea grass, green panic and guatemala grass which have been planted in some areas as forage crops and as erosion controlling strips in parts of the Usambaras.

There would seem to be great scope to increase the area sown to improved grass and legume species in most areas of Tanga Region. In the remaining areas of shifting cultivation, a grass phase could possibly replace the bush regeneration phase, while in the more permanent cultivation areas even a limited area of rotational pasture would assist in maintaining and improving soil fertility as well as providing valuable grazing and an extended growing season.

As with ranch development, there are many technical obstacles to overcome, and in that it represents a shift in land use a number of social problems would also be encountered. If it could be successfully introduced on a limited number of villages in suitable areas however, there is every possibility that over the long term this approach could have a dramatic effect both on the number and quality of stock owned by ujamaa villages and smallholders.

Improved Pasture Species

As mentioned earlier in this section, extensive field scale research is required before detailed recommendations can be made on the most suitable grass and legume species for any specific area. The following list of potentially suitable species is therefore provisional.

Grasses

Buffel Grass	Cenchrus ciliaris
Guinea Grass	Panicum maximum
Green Panic	Panicum maximum var. trichoglume
Rhodes Grass	Chloris gayana
Setaria	Setaria anceps
Singnal Grass	Brachiaria decumbens

Legumes

Glycine	Glycine wightii
Siratro	Macroptilium atropurpureum
Stylo	Stylosanthes guyanensis (Schofield)
Puero	Pueraria phaseoloides

Innoculum

In order to achieve satisfactory root nodulation and production in legumes it is usually desirable in innoculate all legume seed. At present it is virtually impossible to obtain innoculum of any type in Tanga Region - a deficiency which will have to be overcome if highly productive legume/grass pastures are to be established.

3.5.3 Water Supplies

To improve the efficiency of production from the existing livestock population and allow numbers to be increased, it will be necessary to improve and extend stock watering facilities.

This may be undertaken to a large extent in conjunction with the village water supply programme. There will however remain very large sections of the Region which will still not be adequately watered. Although it would be technically feasible for the State to provide water in these areas, the cost would be enormous. It is therefore suggested that most investment in stock watering facilities apart from the village supply schemes should be left to the villages themselves. Exceptions of course will occur, particularly along stock movement routes.

The approximate number and costs of livestock watering points within the individual village and grouped water supply schemes are analysed in Technical Report 8, Climate and Water Requirements.

3.5.4 Future Livestock Numbers

Stocking intensities for the year 1995 have been estimated per agro-economic zone on the assumption that:

(a) water is limiting; this is the present situation in relation to watering points

(b) water is not limiting; i.e. if costs are non-limiting in the construction of water supply systems for livestock.

To arrive at the estimates the following procedure was followed.

(1) Livestock units by agro-economic zone were calculated from the extrapolated survey data. Since poultry are insignificant contributors to grazing pressure, they have been excluded.

(2) The estimated increase in population densities between 1975 and 1995 were calculated in per cent per agro-economic zone (see Volume V, Chapter 2).

(3) The area available for grazing was evaluated by each agro-economic zone on the basis of:

  (a) livestock units per total agro-economic zone area (excluding forest reserves).

  (b) livestock units per grazing - and - unused-land are (deduction of built up areas, arable land etc. from the total).

  (c) ecological conditions in each agro-economic zone (estimates based on rainfall data).

  (d) soil types and topography of each agro-economic zone (estimates based on descriptions and field observations).

(4) The following assumptions were taken into consideration:

  (a) that livestock intensities would increase more than any increase in population density if the area available for grazing and the water supply for cattle were non-limiting

  (b) that areas heavily infected by tsetse flies seriously limit the possibilities to increase cattle numbers.

  (c) that marked increases in population numbers in densely populated areas will lead to a decrease in stocking intensities (expansion of arable land at the expense of the area available for grazing)

  N.B. poultry is not subject to the foregoing condition; numbers are likely to increase more than population densities.

The present and likely future carrying capacity of each agro-economic zone is summarised in the following Table.

Table AG 3-2 : PRESENT AND LIKELY FUTURE LIVESTOCK CARRYING CAPACITY BY AGRO-ECONOMIC ZONE

AEZ	Area Sq. km.	Present Carrying Capacity L.U./Sq.km. 1)	Likely 1995 Water Limiting L.U./Sq.km.	Carrying Capacity Water Non-Limiting L.U./Sq.km.
H1	2893	5.5	9.6	13.8
2	4572	9.7	16.5	21.3
3	2463	4.3	6.5	7.5
3/4	1254	27.2	30.0	30.0
4	2027	11.6	16.2	20.9
K1	286	34.6	27.7	27.7
2	1884	27.2	38.1	46.2
3	1585	20.9	27.2	31.4
L1	1317	82.0	57.4	57.4
1/2	653	60.9	42.6	42.6
2	1527	10.8	15.1	19.4
M1	1550	6.8	9.5	9.5
2	1219	24.5	19.6	19.6
3	1188	6.9	9.0	13.1
4	974	5.2	6.8	8.3
P1	976	7.4	11.1	13.0
2	448	29.7	44.6	52.0

1) Total area basis from Table AG 2.8 in chapt. 2.3.5

Table AG 3-3: LIVESTOCK NUMBERS BY AGRO-ECONOMIC ZONE

AE ZONE		1000 LIVESTOCK UNITS PER AE ZONE		
		1975	1995 Probable (water limiting)	1995 Possible (water not limiting)
Handeni	1	15.9	28	40
	2	44.0	75	97
	3	10.5	16	18
	3/4	34.1	38	38
	4	23.6	33	43
Korogwe	1	10.1	8	8
	2	50.5	71	86
	3	33.0	43	50
Lushoto	1	107.7	75	75
	1/2	38.2	27	27
	2	16.5	23	30
Muheza	1	10.3	14	14
	2	29.8	12	16
	3	8.2	11	16
	4	5.1	7	8
Pangani	1	7.2	11	13
	2	13.3	20	23
Total		458.0	512	602

3.5.5 Livestock Markets and Stock Routes

Livestock Markets

The main marketing centres in Tanga Region are located at:-

Secondary Market - Korogwe

Local or Town Markets

Handeni District	-	Handeni Kiberashi Songe Balanga
Korogwe District	-	Manyata Mkomazi Kalalani
Lushoto District	-	Lushoto Kwekanga Mkundi Malindi Kivingo
Tanga District	-	Tanga Town

Further information on livestock marketing is given in TIRDEP: Tanga Regional Development Plan,1975-80, Volume 3.

Stock Routes - Present

Almost all livestock in the Region are walked to market.

A large proportion of stock movement is essentially of stock to the local markets. The distances involved are thus short and in general there are no declared stock routes, nor any need for them. Water supply can certainly be a problem in the dry season, but this should be adequately covered by the village water supply schemes proposed in the Tanga Water Master Plan.

The main stock movements outside local areas are into Handeni Town from West Handeni, from Handeni Town to Korogwe, from Korogwe and Muheza to Tanga and less important routes down the Mkomazi Valley to Korogwe. The most important route, from Kiberashi to Handeni and Korogwe, has been studied in detail by TIRDEP[1].

1) TIRDEP, Working Paper No. 24, Improvement of Water Supply and Veterinary Services for the Handeni Cattle Stock Route.

In general the water supply situation is unsatisfactory along many of the routes, with large distances between watering points which often do not provide adequate supplies due to unserviceability.

Future Situation

As herd numbers and production efficiency increase, it is inevitable that more cattle will use the major stock routes, placing even to unserviceability.

It will therefore be desirable if consideration can be given to the provision of watering facilities on stock routes when individual or grouped village water supply schemes are being implemented.

3.6 UNIT IRRIGATION WATER REQUIREMENTS

3.6.1 Introduction

An important objective of the Water Master Plan is to investigate and to assess the availability of surface and/or groundwater for irrigation purposes. Since water is in most cases the limiting factor for agricultural development, it was felt necessary to determine the water requirements for irrigated crops. These figures in conjunction with the results of the soil survey will enable an assessment of the possible future water demand and the irrigation potentials in the Region. It should be noted that both hydrologic phenomena and water demand in a region or river catchment are of random nature. In matching demand and supply the stochastic nature of both has significant effects on planning the developments and use of water resources.

It was therefore considered useful to estimate irrigation requirements as random variables, in which random variations are superposed on seasonal or periodic fluctuations.

In respect to the evalution of the hydrological water balances only irrigation requirements for average and very dry conditions have been considered, with 50 % and 10 % probability of exceedance.

3.6.2 Meteorological Data

The available meteorological data for the Tanga Region (see Technical Report No.4, Vol. I) have been used as the basis for the determination of the consumptive use of irrigated crops.

The procedure of calculation of evaporation and potential evaportranspiration is discussed in Chapter 2.1. above. A summary of open water surface evaporation (E_o) values is given in Technical Report No.8. It should be mentioned that the processed data from "Wami Railway Station" have been omitted because of their obvious unreliability

Monthly rainfall figures were derived from the cumulative frequency curves for stations which have more than 20 years of records (see Technical Report No. 17). Frequency analyses were applied to some stations with less than 20 years of records, when they appeared to be essential for irrigation requirement assessment.

3.6.3 Procedure of Calculation

Potential crop evapotranspiration[1] (E_{po}) is defined as the actual evapotranspiration of the plant when soil moisture stress does not occur and the soil is evenly covered by the crop. E_{po} is always related to a certain reference value ("evaporative demand") which can either physically or emperically be derived from meteorological data. (see Chapter 2.1).

It was decided to use the evaporation of an open water surface (E_o) as the reference value, since crop factors, expressed as proportion of this value (E_{po}/E_o), could be provided for most of the crops in question

Effective precipitation has then been deducted from potential evapotranspiration to obtain the net irrigation requirement expressed in m^3/ha per month. Net requirements have to be adjusted for application losses in order to find the field irrigation requirements.

The arithmetic procedure can be generalised as follows

$$IR(i) = f(i) * E_o(i) - c * P(i) \quad \text{and}$$

$$IR(i)^{field} = IR(i) * \frac{1}{e_a}$$

where
- $IR(i)$ = net requirement in month i
- $f(i)$ = crop factor in month i
- $E_o(i)$ = evaporation of open water surface in month i
- $P(i)$ = total precipitation in month i
- $c * P(i)$ = effective precipitation ($0 < c < 1.$)
- $IR(i)^{field}$ = field requirement in month i
- e_a = field application efficiency.

3.6.4 Stochastic Nature of Monthly Irrigation Requirement

Water requirement of an irrigated crop is composed of a random component superimposed on seasonal or periodic fluctuations. The chance aspects of irrigation water consumption result from the randomness in precipitation, evaporative demand, heat supply and similar climatic factors.[2]

---

1) also referred to as "consumptive use"

2) Note that this random component in irrigation water consumption may be related to the random components in the water supply of rivers and groundwater acquifers.

In this Study irrigation requirements are deterministically derived from the stochastic variables evapotranspiration and precipitation. In order to estimate the requirements with a specific desired probability (for instance 10 and 50%) the randomness of the joint event, that a certain precipitation (P) and evaporation (E_o) occur simultaneously, must be known.

For this purpose the stochastical interdepence of P and E_o has been analysed in Technical Report No. 8, Sect.II . It could then be derived from numerical examples that a monthly irrigation requirement with a specific probability of exceedance can be directly computed from the individual (or marginal) probability distributions of E_o and P as follows:

Marginal probability of non-exceedance (in%)		Joint probability of exceedance of derived irrigation requirement
Evapotranspiration E_o	Precipitation P	IR
80	20	10% ("10% dry month")
80	60	50% (average month)
75	25	20 - 25%
75	75	65 - 70%

(for example IR (0.10) = $f.E_o(0.80) - P_e(0.20)$, where P_e is effective precipitation, which is derived from P, see 3.6.6)

The monthly evaporation and precipitation values with a probability that is required to calculate the irrigation requirements for a "10 % dry" and "average" month are summarized in Table AG 3-4 and AG 3-5.

3.6.5 Irrigated Crops and Crop-factors

Unit irrigation water requirements are calculated for those for which ecological and agro-economical conditions were found to be favourable. Irrigation of some important estate crops has been reglected (tea, coffee, citrus) since their anticipated additional returns on invested capital proved to be too low.

Although rice is at present often grown under rainfed and sometimes dry conditions, additional and controlled water supply is considered indispensible if improved and high yielding varieties and two crops per year are contemplated.

Table AG 3-4

Table AG 3-4: EVAPORATION OF OPEN WATER SURFACE (E_o) IN MM/MONTH PER AGRO-ECONOMIC ZONE
PROBABILITY OF NON-EXCEEDANCE IS 0.80 (4 OUT OF 5 YEARS)
(REFERENCE VALUES FOR CONSUMPTIVE USE CALCULATION)

Agro-Economic Zone Code	Number	Meteoro. Station	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
M P H	1[b], 3[a] 1, 2 1[b]	TANGA	190	162	193	171	161	144	144	140	141	164	171	187
M H	2, 3[b], 4 1[a]	MLINGANO	194	178	180	150	130	123	119	133	147	164	162	184
M K L	1[a] 1 1, 1/2[a]	AMANI	138	120	135	121	116	102	99	101	100	114	119	138
K H	2[b], 3[b] 2	MOMBO	186	158	184	163	141	123	120	126	127	153	168	184
K H	3[a] 3, 3/4, 4	SAME	170	145	168	157	126	110	112	114	122	144	154	168
L K	1/2[a], 2 2[a]	KALIMAWE	189	160	189	171	153	122	121	116	125	174	173	186

Table AG 3-5: MONTHLY PRECIPITATIONS PER AGRO-ECONOMIC ZONE IN MM

Agro-Economic Zones	Weighted Average From Rainfall Stations	Probability of Non-Exceedance	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
M2	Kiwanda, Muheza Fac. Ngomeni, Pongwe, Kigombe	0.20	10	12	44	112	120	20	22	25	21	38	41	33
		0.60	46	43	109	279	233	65	55	57	63	114	136	110
P1, M1[b]	Pangani, Mwera Kiwanda, Hale	0.20	11	7	49	139	124	22	22	21	18	31	40	32
		0.60	45	40	112	246	236	65	57	57	59	90	122	99
P2, H1[b]	Sakura	0.20	9	6	42	120	110	18	14	28	20	25	38	28
		0.60	40	36	130	240	200	62	80	60	55	80	115	90
M4	Mwakijembe	0.20	3	2	50	6	6	5	-	-	-	-	-	-
		0.60	40	39	88	80	71	35	-	-	-	-	14	30
K2[a]	Magoma	0.20	11	9	40	70	68	8	12	9	3	7	10	24
		0.60	54	46	92	175	130	36	32	27	22	75	64	65
K2[b]	Lwengera, Korogwe Mandera, Hale	0.20	11	10	35	154	130	17	15	17	8	24	2	9
		0.60	42	41	88	258	237	60	51	46	37	76	64	51
K3[a]	Buiko, Mabogo	0.20	-	8	17	35	36	-	-	-	-	-	11	16
		0.60	81	39	72	89	69	25	4	3	2	18	48	47
K3[b]	Mazinde S.E., Kikwajuni	0.20	25	24	32	80	75	4	4	1	-	-	33	32
		0.60	60	61	93	151	170	25	16	11	16	23	66	116
L1[a]	Lushoto, Magamba Lwandai	0.20	47	35	78	115	88	11	9	3	1	8	61	95
		0.60	98	85	160	188	167	30	28	14	8	40	116	173
L1[b]	Mazumbai, Balangai Herkulu	0.20	23	25	53	127	156	24	22	18	13	14	32	46
		0.60	66	67	120	242	300	72	65	55	49	71	102	96

Table AG 3-5 (contd)

Agro Economic Zones	Weighted Average From Rainfall Stations	Probability of Non-Exceedance	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
L1/2[a]	Lwandai, Malindi Shume	0.20	33	29	64	84	36	-	-	-	-	8	55	69
		0.60	89	70	132	153	74	5	5	3	7	35	110	193
L2, L1/2[b]	Mnazi	0.20	5	1	28	40	11	-	-	-	-	-	60	120
		0.60	58	36	130	155	50	-	-	-	5	20	165	215
H1[a]	Mzundu, Kwamgwe	0.20	4	15	55	113	66	6	12	10	14	24	12	11
		0.60	47	36	104	180	158	45	37	30	35	88	113	74

Calculation of water requirements have been carried out for those agro-economic zones where significant irrigation potentials can be found (see Chapter 3.8). Several agro-economic zones had to be divided in to sub-zones, due to strong differences in climate and rainfall pattern (see Chapter 2.4). The meteorological and rainfall stations which have been used to assess unit water requirements, as well as the boundaries of the agro-economic subzones are displayed in Fig AG 3-1.

Crop factors which relate evaporation (E_O) to potential evapotranspiration depend mainly on the growing stage and the type of crop and for a much less extent on the time of the year. Since no experimental values of these factors exist for Tanga Region, they were compiled from various publications. In Table AG 3-6 the applied crop factors are shown for the various proposed crops. It should be born in mind that the indicated planting dates and growing seasons can never to entirely fixed, since they depend very much on factors like labour and water availability, rainfall pattern and crop variety. Consequently the water requirement calculation allows for slightly moving planting dates, so as to obtain the average requirements per hectare.

3.6.6 Effective Precipitation

Effective precipitation is defined as the proportion of total precipitation which can be used by the plant for actual evapotranspiration. The unutilized part is distributed over surface run off, deep percolation and evaporation from ponds. The rate of utilization depends therefore on many factors such as rainfall intensity infiltration capacity, antecedent precipitation, soil moisture capacity, rootdepth, slope of land, irrigation method and potential evapotranspiration. It is obvious that taking into account all these factors would lead to undesirable complexity of the problem. In addition most of the factors are not known since one is dealing with monthly precipation values.

Coefficients to convert total into effective precipitation are summarized in Table AG 3-7.

For irrigated rice grown in levelled basins it is assumed that rainfall is effective upto 50, 100 and 150 mm in the respective first, second and third month after transplanting. In addition, a pre-irrigation of 50 mm is allowed for each rice crop.

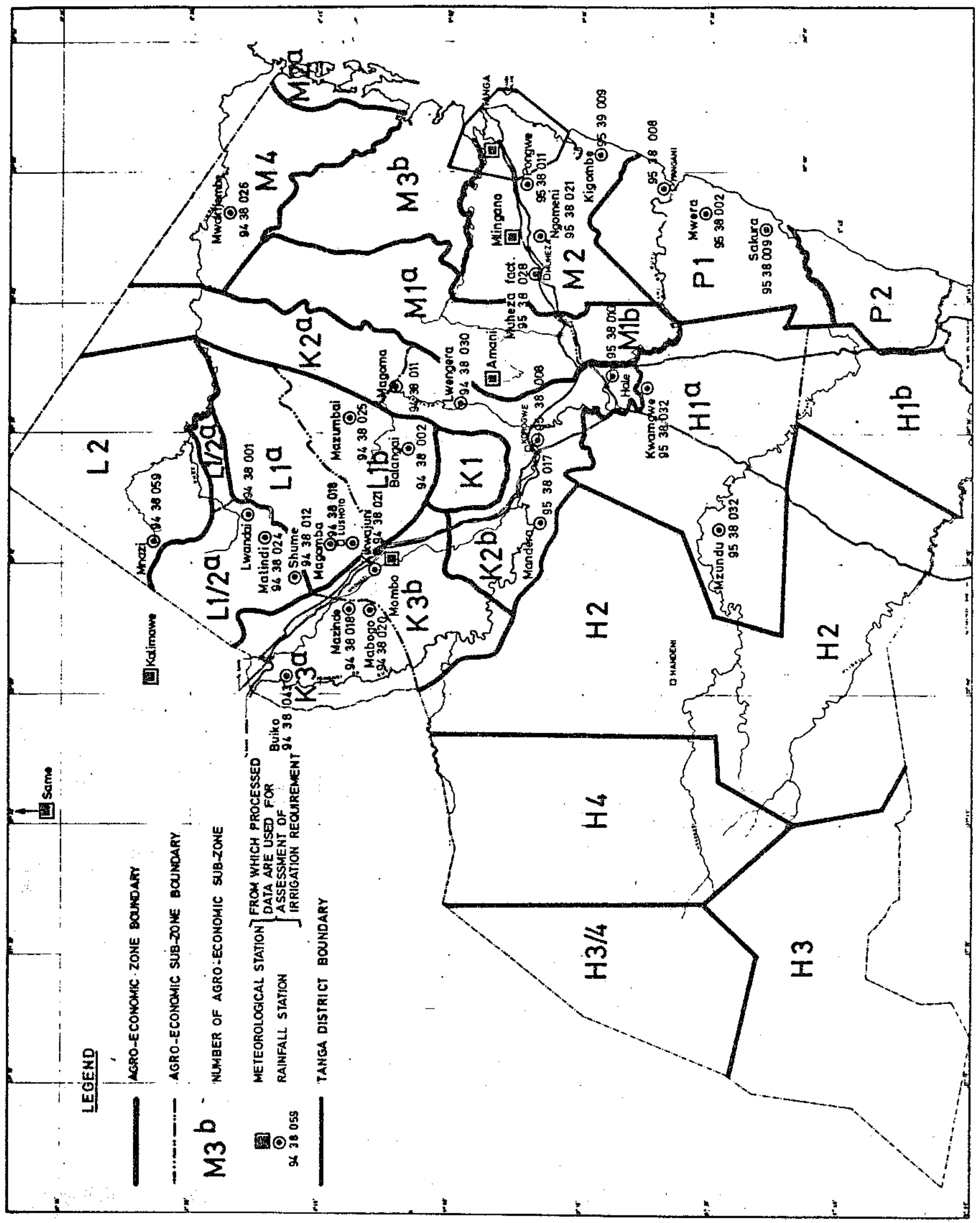

FIG. AG 3-1

Table AG 3-6

Table AG 3-6: CROP FACTORS EXPRESSED AS PROPORTION OF MONTHLY EVAPORATION FROM AN OPEN WATER SURFACE (E_o)

			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RICE	Early maturing IRRI varieties suitable for transplanting in lowland	RICE I				0.90	1.00	1.10	0.30[1]					
		RICE II	0.30[1]									0.90	1.00	1.10
BANANAS	Local varieties		0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
MAIZE	Early maturing lowland varieties (hybrids or composites)	MAIZE I (4 m'th)			0.50	0.80	0.90	0.60						
		MAIZE II (5 m'th)	0.60								0.50	0.70	0.90	0.80
SUGAR CANE	High yielding BARBADOS varieties (Lowland)	PLANT CROP I (14 m'th)											0.30	0.50
			0.70	0.85	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.00[2]
		RATOON I (12 m'th)	0.20	0.30	0.50	0.70	0.90	0.95	0.95	0.95	0.95	0.95	0.95	0.00[2]
		PLANT CROP II (14 m'th)					0.30	0.50	0.70	0.85	0.95	0.95	0.95	0.95
	B 41227 B 47419		0.95	0.95	0.95	0.95	0.95	0.00[2]						
		RATOON II (12 m'th)	0.95	0.95	0.95	0.95	0.95	0.00[2]	0.20	0.30	0.50	0.70	0.90	0.95
COTTON	American Upland or UKA Varieties (5 months) [3]			0.30	0.70	0.80	0.90	0.50						
					0.30	0.70	0.80	0.90	0.50					
VEGETABLE CROPS, BEANS	Tomatoes peppers, egg plants, okra-cucumber, etc.	FIRST CROP			0.60	0.80	0.80	0.70						
		SECOND CROP	0.70									0.60	0.80	0.80
IRISH POTATOES	Highland (USAMBARAS)[4]			0.55	0.75	0.80	0.80							
			0.75	0.80	0.80									0.55

1) Irrigation is stopped 3 weeks before harvesting
2) Fields should dry out before cutting cane
3) Varying planting dates from Feb. to Mar.
4) Varying planting dates depending on rainfall pattern

3.6.7 Unit Water Requirements by Agro-Economic Sub-zone

All basic calculations of unit water requirements can be found in Technical Report No.8 Section II.

3.6.8 Annual Unit Water Requirement for a 10%[1] and Average Rainfall Year

Unit water requirements as calculated in Technical Report No. 8 are monthly values for 10% and 50% probability of exceedance. It should be note that summation of 12 monthly values with, for instance, a 10% probability, does not necessarily yield the annual water requirement in a 10% dry year.

Annual water requirements in a 10% rainfall year should therefore preferably be derived from actual rainfall and evaporation data of a selected 10% rainfall year (annual rainfall exceeded nine out of ten years) with an approximate "normal" distribution of rainfall.

Since only frequency distributions and not time series of evaporation are available for all stations (except Mlingano), it was not possible to directly calculate the total annual evapotranspiration for a specific 10 or 50% rainfall year.

However, a direct calculation was possible for data from Mlingano station, which has complete monthly time series of Penman evaporation values. Annual water requirement calculations in agro-economic zone M_2 were made for two specific years of which the annual rainfall was equal to about the rainfall with a respective 10 and 50% probability total requirements obtained by summation of the 10 or 50% monthly requirements. The average ratios of annual water requirements for a 10% dry year (or average year) to the sum of 10 (or 50%) monthly requirements were then assumed to be applicable to all agro-economic zones in Tanga Region. It must be borne in mind that the so obtained ratios are only a rough approximation, because they depend very much on the distribution of rainfall and evaporation in the selected 10 or 50% dry year.

Since rainfall distribution affects the irrigation requirement of rice more than for other crops, the conversion from monthly to annual requirements was additionally estimated for agro-economic zone K_3^b (evaporation distribution in 10 and 50% rainfall year was synthesized for this purpose). The results are summarized in Table AG 3-9.

1) Specific year with annual rainfall nearest the 10% probability of non-exceedance for the rainfall station chosen.

Table AG 3-7 EFFECTIVE PRECIPITATION

Ratio of consumptive use to total precipitation ($f*E_o$: P)	Coefficient to convert total precipitation into effective precipitation	
	Fine textured soil	Medium textured soil
0	0.00	0.00
0 - 0.2	0.10	0.20
0.2 - 0.4	0.20	0.30
0.4 - 0.6	0.30	0.40
0.6 - 0.8	0.40	0.50
0.8 - 1.0	0.50	0.60
1.0 - 2.0	0.60	0.70
2.0 - 3.0	0.70	0.80
3.0 - 4.0	0.80	0.90
4.0 - 5.0	0.90	1.00
5.0	1.00	1.00

3.6. 9 Irrigation Method and Application Efficiency

An assessment of field application efficiencies has to be made in order to determine the irrigation requirement on field level. The following Table shows the assumed efficiencies for the proposed irrigation methods.

Table AG 3-8 FIELD APPLICATION EFFICIENCY

Crop	Soil texture	Irrigation method	Application efficiency %	
			Actual	Improved
Rice	Fine	Basins (levelled)	50	70
Bananas	Medium	Furrows	50	60
Maize	Medium	Borders	60	70
Sugar Cane	Fine	Furrows	-	60
Cotton	Medium	Furrows (furrow basins)	-	60
Vegetables Beans	Medium	Furrows	60	70
Irish Potatoes	Medium	Furrows	60	70

Table AG 3- 9 CONVERSION FROM MONTHLY TO ANNUAL IRRIGATION REQUIREMENTS

Crop	Rice		Sugar Cane	Vege-tables	Maize	Bananas
Derived from data in A.E. Zone	M_2	K_3b	M_2	M_2	M_2	M_2
Sum of 10% monthly requirements in m^3/ha	10,978	12,405	12,847	7,624	9,188	22,561
Annual requirement of 10% dry year in m^3/ha	8,961 (1970)	11,491 (1959)	10,623 (1970)	6,464 (1970)	8,348 (1970)	19,211 (1970)
Ratio	1.23	1.08	1.21	1.18	1.10	1.17
Applied conversion factor	1.16	1.16	1.20	1.15	1.15	1.15
Sum of 50% monthly requirements in m^3/ha	8,153	8,722	7,903	3,599	5,025	15,615
Annual requirement of 50% dry year in m^3/ha	8,318 (1953)	10,134 (1960)	8,054 (1953)	4,037 (1953)	6,378 (1953)	15,625 (1953)
Ratio	0.98	0.86	0.98	0.89	0.79	0.99
Applied conversion factor	0.92	0.92	0.98	0.89	0.89	0.89

Conversion factors for Irish potatoes and cotton were assumed to be equal to the average factor for vegetables, maize and bananas.

3.7 UNIT LIVESTOCK WATER REQUIREMENTS

3.7.1 Introduction

Many factors affect the water requirements of the various classes of livestock, including

- breed
- size
- condition
- milk yield
- climate
- pasture conditions
- quantity and type of feed
- distance to grazing and watering points
- required safety margin
- management system
- frequency of watering

In this section the requirements of livestock for drinking water (other than water supplied from pasture or short term surface ponding) are analysed assuming that:

Water requirement = Maximum water requirement less rainfall factor less pasture factor

3.7.2 Maximum Water Requirement/Temperature Factor

Temperature is the major factor affecting maximum water requirement, and the following relationship is likely (Livestock Unit Basis).

Mean Temperature °C	Max Water Requirement l/LU/day
18	19.4
20	20.8
22	22.2
24	23.6
26	25.0
28	26.4

These data refer to Bos indicus cattle and local sheep and goats. European breeds would require approximately 40% more water.

Water demand is also affected by relative humidity, with high RH values reducing demand. In genral terms RH is higher at the coast than inland and is higher during and after the long rains than at other periods, but insufficient data is available for the region for these variations to be accurately quantified. They are thus assumed to be adequately covered by the temperature, rainfall and pasture factors.

Table AG 3-10: LIVESTOCK UNIT WATER REQUIREMENTS

Dry Year (Litres/LU/Month)

AEZ	J	F	M	A	M	J	J	A	S	O	N	D	Year
H1	710	390	590	530	530	620	620	660	650	720	520	720	7260
H2	710	390	590	530	530	620	620	660	650	720	520	720	7260
H3	540	290	370	510	490	590	590	450	580	640	450	680	6180
H3/4	540	290	370	510	490	590	590	450	580	640	450	680	6180
H4	710	390	590	530	530	620	620	660	650	720	520	720	7260
K1	530	450	550	660	250	470	460	460	600	450	330	520	5730
K2	710	390	590	530	530	620	620	660	650	720	520	720	7260
K3	500	600	810	740	710	690	690	690	660	760	750	710	8390
L1	530	450	550	660	250	470	460	460	600	450	330	790	5730
L1/2	530	450	550	660	250	470	460	460	600	450	330	520	5730
L2	750	690	620	560	660	640	650	660	630	550	520	710	7640
M1	680	480	550	220	220	260	270	420	460	340	500	540	4740
M2	780	570	790	400	510	710	730	720	690	540	620	600	7660
M3	780	570	790	400	510	710	730	720	690	540	620	600	7660
M4	750	690	620	560	660	640	650	660	630	550	520	710	7640
P1	780	570	790	400	510	710	730	720	690	540	620	600	7660
P2	780	570	790	400	510	710	730	720	690	540	620	600	7660

Average Year (Litres/LU/Month)

AEZ	J	F	M	A	M	J	J	A	S	O	N	D	Year
H1	570	500	430	350	370	520	640	650	630	670	550	560	6440
H2	570	500	430	350	370	520	640	650	630	670	550	560	6440
H3	500	320	390	220	360	580	570	580	580	600	490	510	5700
H3/4	500	320	390	220	360	580	570	580	580	600	490	510	5700
H4	570	500	430	350	370	520	640	650	630	670	550	560	6440
K1	510	450	360	220	220	460	570	580	580	500	350	500	5300
K2	520	500	430	350	370	520	640	650	630	670	550	560	6440
K3	620	600	650	500	590	680	690	690	660	750	720	770	7920
L1	510	450	360	220	220	460	570	580	580	500	350	500	5300
L1/2	510	450	360	220	220	460	570	580	580	500	350	500	5300
L2	750	670	600	530	650	620	640	650	630	540	390	600	7270
M1	510	450	330	220	220	310	310	410	290	280	220	330	3880
M2	780	710	630	360	240	470	590	570	540	540	430	620	6480
M3	780	710	630	360	240	470	590	570	540	540	430	620	6480
M4	750	670	600	530	650	620	640	650	630	540	390	600	7270
P1	780	710	630	360	240	470	590	570	540	540	430	620	6480
P2	780	710	630	360	240	470	590	570	540	540	430	620	6480

3.7.3 Pasture Factor

The pastures grazed by livestock contain varying percentages of water, dependent on seasonal conditions and their stage of growth. Four classes are considered.

	Dry Matter %	Water Supplied from Pasture 1/LU/month
0	70 +	-
1	50 - 70	100
2	40 - 50	200
3	40 -	300

3.7.4 Rainfall Factor

During periods of moderate to heavy rainfall, livestock are able to obtain a high proportion of their water requirements from water on plant surfaces or temporarily stored in pools on the ground. This factor is difficult to quantify but for calculation purposes one 1/LU/month is deducted per millimetre of rainfall received during that month, up to a maximum of 2/3 total requirement.

3.7.5 Livestock Unit Water Requirements by Agroeconomic Zone

The calculation of water requirements by agro-climatic zone are given in Technical Report Number 8. The results of these analyses are given in the following Table AG 3-10 for:

a) A 10% dry year, i.e. the specific year nearest the 10% probability of non-exceedance for the rainfall station chosen

b) An average year, based on mean monthly rainfall data.

If these data are used for the design of livestock watering schemes the following points should be borne in mind.

- peak requirements normally exceed average requirements by at least 25%, and an additional margin of safety is also required.
- allowance must of course be made for seepage, evaporation and silting for earth dams, and for pump breakdown in pump schemes.

3.8 IRRIGATION AND DRAINAGE

At present irrigation in the Tanga Region is of very little importance and widely neglected. Considerable virtualy unused areas, however, seem to be well suited for irrigation, in particular the major alluvial valleys. Since the Water Master Plan is aimed at providing a future allocation scheme of potential water resources, an assessment of irrigation potentials and corresponding water demand is a logical part of this Study.

This chapter is dealing with the assessment of potential irrigable areas, as far as the soils and physiography are concerned. Based on these potential areas the potential water demand will be estimated in the next section, which is to provide the basic data for the water balance per sub-catchment area. Analysis of both potential demand and potential resources will furthermore lead to the evaluation of potential irrigation projects (section 5).

Drainage can not be regarded as a separate subjects since it is in most cases an inevitable part of land improvement. The most suitable irrigation areas are commonly floodplains or alluvial valleys, which are mutatis mutandis poorly drained and have sometimes waterlogged soils. Irrigation of these areas will cause a rise of the watertable and consequently the danger of salinization. A proper drainage system is therefore required, which has to prevent the irrigation area from seasonal flooding as well.

The potential areas are briefly discussed by administrative districts belowand their location is displayed on Drawing AG 3-1.

A KOROGWE DISTRICT

A1 UPPER MKOMAZI VALLEY

Development proposals[1] are available for the upper valley of the Mkomazi river (from Bendera to Mikocheni), however, technical problems may arise in training the ill-defined water coarse. In order to ascertain the water supply during the irrigation season, the river flow has to be regulated in conjunction with the Kalimawe Dam Authority.

Since the greatest part of this area is located in Kilimanjaro Region it is beyond the scope of this Report. Water requirements for irrigation however will have to be estimated for the water balance. The maximum net irrigable area has been estimated at some 800 ha.

---

1) See Technical Report No 20, Section III

A2 MIDDLE LOWER MKOMAZI VALLEY

The Mkomazi Valley downstream of Lake Manka offers good possibilities for mechanized irrigated agriculture, but on the other hand presents some serious technical problems. A first development proposal has been made by Halcrow & Partners[1)] for a part of this valley (from Mazinde to Mombo) and several smaller investigations have been undertaken since.

Since the discharge of the Mkomazi river is in no way sufficient for large scale irrigation (with double cropping), it is assumed that additional water can be diverted from the Pangani river and conveyed to the Mkomazi Valley[2)].
The technical feasibility of this assumption has been subject of a separate study (AHT: Reconnaissance Study Lower Mkomazi Valley, Oct. 1976).
The valley is sometimes only a few kilometers wide and the ill-defined meandering river will have to be trained and canalised. The irrigation area can be commanded only by contour canals along the upper edges of the valley bottom. These canals will be very long, the longitudinal gradient in the valley is about 1 per thousand, which means in turn that a great number of intake weirs in the river can be avoided.

Highly saline soils, which lie in long discontinous strips on either side of the valley, should not be brought under irrigation if better lands are still available, since some serious technical and economical problems may emerge from reclamation.

Irrigation is therefore confined to the clay flats, the silty river levees and the alluvial fans of tributaries, which implies that irrigation plots will be irregularly distributed over the area. Drainage of the clay flats is poor because of low gradients and heavy textures so that the water table tends to be high and the groundwater dangerously saline. Supply of additional irrigation water will alter the annual water balance and requires much attention to drainage. Leaching of the soils with water might become necessary in the dry season, if the electro-conductivity tends to increase.

Soils which will still be flooded or waterlogged during several months in the rainy season after the irrigation and drainage system has been implemented, should most preferably be confined to irrigated rice cultivation.
The remaining suitable soils of the valley, which tend to be light in some areas, can be used under well drained conditions for upland crops under borderstrip and/or furrow irrigation. The length of the plots will mainly depend on the soil intake characteristic and the slope of the land.

---

1) W. Halcrow & Partners; The Development of the Pangani River Basin, London 1962.

2) Waterrights at Hale for hydropower do restrict the flows which may be diverted and hence storage of water in Lake Manka will be inevitable if the potential area is to be irrigated.

From a prelimanary aerial photo interpretation the following approximate areas were derived:

Total area downstream of Majengo and below an average commanding level of about 1430 ft (50,000 Maps) : 25,800 ha.[1)]

	Suitable Soils for		Area not considered suitable (ha)	
AEZ	Rice ha	Upland crops ha	Saline soils or back swamps	Foot slopes or undulating upland ha
K_3^a	2,700	1,600	830	820
K_3^b	5,660	2,500	1,450	2,100
K_2^b	1,680	1,190	360	4,880

For calculation of the potential irrigation demand it is assumed that the net irrigable area equals 80% of the total suitable area. Since annual rainfall increases substantially towards the southern edge of the valley, irrigation of upland crops has been considered unfeasible in AEZ K_2^b.

The total net irrigable area therefore amounts to 11,200 ha of which about 8,000 ha are solely suited for rice.

Detailed information on soil suitable for irrigation has been provided in the Reconnaissance Study of the Lower Pangani Valley. Irrigation of suitable areas above the commanding level (foot hills) by pumping from the main canals is not further considered.

In order to ensure a regular water supply throughout the whole year, especially if more intensive agriculture is contemplated, an independent Irrigation Authority should be responsible for the main and secondary irrigation network, assisted by field officers and ditchriders. The tertiary distribution systems can then be operated and maintained by the involved cooperative irrigators or Ujamaa Villages.

---

1) Assumed dead storage level in Lake Manka is 1435 ft

The already recommended Pilot project (see chapt. 3.2) should preferably be implemented on the existing Mombo Irrigation Scheme for two reasons:

(1) rehabilitation and eventually extension of the neglected scheme will anyhow be necessary;

(2) no additional works have to be undertaken to supply irrigation water (water will be abstracted from the of Soni river) and the scheme can be operated independently the future development of irrigation projects in the Mkomazi valley.

A3 LOWER LWENGERA VALLEY

In the Lwengera Valley (main tributary of the Pangani river) heavy textured, dark brown clay soils are situated in narrow strips along the river. The soils are imperfectly drained vertisols, which are not or hardly saline and therefore only suited for rice cultivation if water is available. In addition a few better drained areas occur on the edge of the valley bottom (alluvial fans of small tributaries), which are suited for upland crops.

The total lower valley covers an area of about 17,000 ha, which comprises some 8,000 ha of flat irrigable land, the remainder being hilly land and undulating upland. The southern part of the valley, south of the railway Muheza-Korogwe and along the Pangani river, is only considered very marginaly suitable for irrigation since it is poorly drained and regularly flooded by both the Pangani river and some of its tributaries.

The potential net irrigable area (north of the railway) is estimated at 4,900 ha suitable for rice and some 600 ha suitable for uplands crops.

Irrigation of the footslopes and uplands (pumping) is not likely to be feasible, since in particular the western edge of the valley, receives sufficient rainfall ($\approx$1200 mm) for good upland cropping.

For detailed planning of irrigation lay-out and water distribution, topographical surveys on a scale of 1:5,000 are required. Small village irrigation projects can be developed on both sides of the river and existing schemes should be repaired and improved. Water can be abstracted directly from the Lwengera river or its tributaries (e.g. Nkole river) by simple weirs and intake structures. Special attention should be paid to the drainage of low lying swampy areas, even if rice is to be grown. Bananas and coconut trees can be grown along the riverbed and do not require special irrigation.

Rehabilitation of existing schemes is recommended prior to any further development and the improved Mahenge scheme (Nkole river) is proposed to become a pilot or demonstration project.

In the southern part of the valley at present some rice is grown by flooding in the wet season. If reclamation and drainage of this area is possible, it could alternatively be used for pasture land.

A4 MASHEWA SWAMPS

Heavy textured soils similar to those in the lower Lwengera Valley occur north of Magoma in the narrow valley of the Kumba and Mvilingano rivers (tributaries of the Lwengera river), but here the soils tend to be rather saline ("gleyic solonchak"). The valley is covered by swampy vegetation and is virtually unused. Drainage is very poor and surface runoff accumulates on the valley bottom.

It has previously been proposed to dam the valley and to store water in the swamps for irrigation purposes in the lower Lwengera valley. Since the catchment area of the Mvilingano and Kumba rivers (PN 6) is situated in a relatively low rainfall area, it is doubtful whether sufficient runoff can be trapped to fill the reservoir.

It is therefore alternatively proposed to reclaim the swamps and to improve them for rice cultivation in the main wet season (March-July). A relatively simple irrigation system can be applied to distribute runoff water to the rice fields. The total net potential area has been estimated at 500 ha.

A5 KWAMNGUMI

The existing rice irrigation project (and fishponds) of the Prisoners Camp along the Pangani river seem to be apt for rehabilitation and extension. The soils are of the alluvial type and similar to those in the Lwengera valley and therefore only suited for rice. It is estimated that controlled rice irrigation can be extended to an area of some 500 ha.

B MUHEZA DISTRICT

B1 MISOSWE IRRIGATION SCHEME

A small valley (about 300 ha) of the Mruka river (tributary of the Sigi river) at the slopes of the Eastern Usambaras, has been the subject of an irrigation proposal. A storage reservoir and main supply channel are under construction and are due to command an area less than 150 ha with mainly upland crops (deep red and yellowish clay loams).

Irrigation of upland crops, however, must be considered very doubtful since average rainfall exceeds 1300 mm per year in this area.

B2 LOWER SIGI

Small scale irrigation along the Lower Sigi river (sub-catchment SI4) has been considered by Kilimo. Soils are well drained deep sandy loams and only suitable for upland crops if brought under irrigation. The total area has arbitrarily been estimated at some 400 ha, for which water will have to be pumped from the river at a total lift of about 20 to 30 metres.

B3 MWAKIJEMBE IRRIGATION PROJECT

Near Mwakijembe village an irrigation project has been previously proposed (see Technical Report No. 8). Irrigation in this area along the Umba has good prospects, since the very erratic rainfall pattern causes complete crop failures in almost every year.

The proposed area of some 500 ha is situated at the south bank of the deep-cut river. Soils are moderately to well drained clays and sands, with a low content of organic matter in the top soil and considered susceptible to erosion. Maize, vegetables and beans are proposed as the most suitable crops.

Since the slopes of the proposed irrigable land are quite steep, surface irrigation of upland crops would require intensive land-levelling and anti-erosive measures. Sprinkler irrigation might therefore be considered as a feasible alternative.

Construction of a weir across the river upstream of the area, as it was previously proposed, is outweighed by the easier pumping solution.

C PANGANI DISTRICT

C1 LOWER PANGANI VALLEY

Although the heavy dark saline clay soils of the Lower Pangani Valley (downstreams of the Pangani Falls) are at first sightconsidered suitable for lowland rice, irrigated sugar cane has alternatively been proposed in chapter 3.2. The special problems involved in rice and sugar cane growing on these soils have been examined in a special study (see AHT: <u>Reconnaissance Study of Lower Pangani Valley</u>, Oct. 1976).

Irrigation of the poorly drained clay plains requires special attention to the following features:

(1) Longitudinal gradient of the river is rather low (0.15%) in the concerned area.

(2) The suitable plains are highly scattered and irregularly shaped. One intake structure at the upstream edge of the area, with a left and right bank contour canal, does therefore not seem to be feasible.

(3) Pumping of irrigation water from the river requires a great number of low lift pumping plants, for which electricity could be provided by either the sugar mill or the Hydro-Power Plant at Pangani Falls at relatively cheap rates.

(4) Electro-conductivity of the Pangani water varies between 0.8 and 1.0 mmhos/cm. When sugar cane is grown, allowance should be made for leaching of salts in the soil profile. A land reclamation phase should precede the construction of any irrigation scheme.

(5) Drainage of the irrigated land requires a dense network of deep drains. Free discharge towards the river however is, at least in the downstream part of the area, only possible during very low tide (tidally influenced watertable) and pump drainage in the rainy season will most probably be necessary. Drainage and irrigation pumps could possibly be combined but it should be noted that the drainage requirement in the rainy season (4 to 5 l/s/ha) is about 4 times as high as the average irrigation requirement (1.2 l/s/ha).

(6) Most of the clay plains are very flat, which will influence the most economical furrow length (mechanized) farming) in an unfavourable way.

(7) The high organic matter in the topsoil (30-40 cm) makes the construction of canals and ditches in this soil rather difficult. Costs of an open main distribution system should therefore be compared with a pipe distribution network, although the strongly swelling clays may give rise to serious foundation problems.

The potential suitable gross area (clay plains) is estimated at some 7,000 ha, whereas the net irrigable area is estimated at 5,000 ha. Assuming that the peak irrigation requirement is about 2 l/s/ha, 10 m^3/sec will be abstracted from the river at maximum. The subsequent possible advance of the salt intrusion front upstream the river should be investigated (damage to coconut plantations downstream of the proposed area!).

D LUSHOTO DISTRICT

D1 WESTERN AND CENTRAL USAMBARA IRRIGATION COMPLEX

Extension and improvement outlines for the traditional slope irrigation in the Usambara Mountains are of a more complex nature and should be subject to a special study.

An assessment of potential irrigable areas can in fact only be made in conjunction with the definition of the ecological development targets in the mountains.

However, as a first approach and for the purpose of the Water Master Plan it has been assumed that the existing irrigation area can only be potentially extended by about 10%, since:

1) high land (and population) pressure is already a fact and should be released;

2) erosion hazard on the irrigated steep slopes and the need for better water conservation are factors against irrigation extension;

3) forest protection and reafforestation interfere with agricultural enterprises;

4) existing schemes can be much improved and the cropping intensified;

Irrigation will be restricted to the growing of vegetables, beans and Irish potatoes, since their returns per m^3 of water are expected to be higher than from other crops.

In addition irrigation of maize and other field rowcrops on the steep slopes raises many erosion problems, which are not easy to control. Irrigation should therefore as much as possible be confined to the valley bottoms and the gentle slopes and both terracing and contour irrigation should be introduced.

The total potential irrigation area has been estimated at some 7,100 ha, the exact location depending on the water and soil availability, the situation of multi-purpose storage facilities and so on.

D2 UPPER UMBA FLOOD PLAIN

The flood plain of the upper Umba river, just at the toe of the Usambara massive near Mlalo, offers excellent possibilities for irrigated agriculture. The soils of the highly flat plain are fairly heavy dark red to yellowish clays with a granular structure and have good yield potentials. The imperfectly to poorly drained soils near the river are considered only suitable for rice (frequently flooded in the rainy season). Maize, beans and possibly cotton should be grown under surface irrigation on the deeper, well drained soils (clay loams) at the outer edge of the plain (along the footslopes of the mountains). Tail water from the irrigated upland crops can be used to flood the lower lying rice fields, in view of obtaining a high water application efficiency. Special attention will have to be paid to the bilharzia problem since it appears that this area is heavily infested.

The existing irrigation schemes (Kitivo and Lunguza) could be rehabilitated and substantially extended, but water seems at first sight the major constraint. The potential irrigable area is therefore arbitrarily confined to the suitable soils on the right bank of the Umba river and is estimated at some 1,500 ha. A pilot scheme for both irrigated and dry farming is recommended.

D3 MNAZI FLOOD PLAIN

The dark grey-brown clay soils ("chromic vertisols") along the Mbaluma river near Mnazi Village are more saline than in the Umba plain and therefore also considered only suitable for rice. However, extension of the irrigation schemes will face some serious water supply problems, unless sufficient storage facilities can be found. The catchment area (UM_1) is situated in a very low rainfall zone.

The potential net irrigated area is estimated at some 1,200 ha of rice and 100 ha of mixed upland crops.

Downstream of the Mnazi scheme, about 300 ha of rice and 50 ha of maize could be irrigated on narrow alluvial strips along the river near Kivingo and Antakea village. Here, too, the bilharzia infestation requires special attention.

E HANDENI DISTRICT

E1 MKALAMO IRRIGATION PROJECT (MSANGASI FLOOD PLAIN)

A feasible dam site exists in the Msangasi river, somewhat upstreams of Mkalamo Railway Station[1].

At an embankment height of 35 meters the maximum impounding capacity of the reservoir will be 74 million m^3. However, most part of the year the river dries up completely and runoff has a rather erratic character. In addition, no records are available of past floods. It is therefore at this stage rather difficult to predict the safe yield of the reservoir, the time distribution of runoff in this case being more important than the total annual runoff.

The proposed irrigation area is the Msangasi flood plain and is situated at the toe of the escarpment about 20 km from the seashore, where the population increased as a result of the railway line works. At present the area is overgrown by a thick mantle of vegetation and sometimes flooded by the Msangasi river. The river bed in the flood plain is ill-defined and some overflow lakes can be found ("Mbuga" land).

1) Dolfi, D.: Reconnaissance Report on a Scheme in the Coastal Plain. The Msangasi River Basin in Tanganyika Dar es Salaam 1963

The topographical lay-out of the area seems to be suitable for irrigation. Once the river flow is controlled no major drainage problems are expected in the flood plain. Soil-samples from two pits in the concerned area indicate low salinity and alkalinity hazard (0.2-0.9 mmhos/cm and PH 6.7 to 7.0) and show sandy loam to loamy sand textures.

The soils of the proposed area can be divided in imperfectly drained heavy textured "mbuga" land which is only suitable for rice (4,500 ha) and the better drained light textured undulating coastal plains suited for irrigated upland crops (2,000 ha) but requiring special attention.

Detailed investigations are required to determine the most suitable crop pattern, irrigation method and drainage requirements.

Finally it should be mentioned that the area is served by a good communication system, viz. an all-weather road of 40 km to the trunk road Dar es Salaam - Tanga and the railway Tanga - Dar es Salaam, which passes at the western edge of the area.

It should be noted that part of the proposed irrigation area is located in the Pangani district (A-E zone P_2).

E2 MNYUSI VALLEY

The flood plain of the Mnyusi river, along the road Korogwe - Handeni is one of the typical "Mbuga" areas, which can be found in several places of the Region. Mbuga are poorly drained alluvial plains the soils of which are heavily textured and flooded during several months and dry up during the rest of the year, the vegetation being adapted to this situation.

Reclamation of these waterlogged areas would be possible without high costs, but irrigation possibilities are predominantly restricted by the water availability. Most of the mbuga soils are considered only suitable for rice cultivation, whereas some of the surrounding footslopes might be suited for upland crops. At present local smallholders manage to grow a little rice during the very wet years, but with improved water supply and drainage systems the potentially irrigable area could be increased to some 2,400 ha, mainly rice.

The possibility of diverting water from the Pangani river and conveying it over a distance of about 5 km to the upper edge of the valley should be examined for its feasibility.

E3 SEGERA VALLEY

Similar considerations as for the Mnyusi plain hold true for the Segera valley. However, water supply will become a much greater problem, since the Pangani river is rather remote and irrigation directly from the Segera river depends solely on the storage possibilities, the river being dry most of the year. The total irrigable net area has been estimated at some 1,650 ha, once again mainly suited for rice (imperfectly drained black clays, non-saline).

E4 MZUNDU VALLEY

A long narrow strip of poorly to moderately well drained, dark clays and sands in the Msangasi valley near Mzundu village also offers potentials for mainly irrigated rice This valley is similar to the mbuga areas since it has stagnant drainage conditions with marshy vegetation. Significant irrigation is only possible if storage facilities can be found. The total potential irrigable area is estimated at some 1,000 ha.

Similar smaller valleys and mbuga areas can be found along various rivers in the Handeni district which offer possibilities for very small scale irrigation. They are not further considered in the water balance and may only be reconsidered after successful experience is obtained from one of the previous "mbuga" projects.

3.9 POTENTIAL LAND USE

3.9.1 General

The term 'Potential Land Use' is not well defined and can be differently interpreted, dependent on the particular planning objectives.

In the pure sense of the word, potential land use should describe and indicate all possibilities or purposes for which a certain land or soil type can be used. However, if strictly following this definition, most of Tanga Region for example could potentially be used as Game Reserve or National Park.

Consequently a more specific definition of potential land use is required. In the context of this study potential land use is therefore defined as the most feasible or recommendable land use, resulting from the interaction of physical potentials and the principle development objectives in Tanga Region.

Since development objectives are not exactly defined in large parts of Tanga Region, it is assumed that agriculture in general and the cultivation of food and cash crops in particular deserves highest priority in the development areas with fast expanding rural population.

Consequently in this predominantly agricultural appraisal, forest and grazing are in general not considered as a high potential type of land use.

3.9.2. Determination of Potential Land Use

The potential use of each specific land or soil type has been derived from a synthesis of all available information, in particular:

- Soil Survey Map (Drawing PE 5-1)
- Land Capability Map (Drawing PE 8-1)
- Erosion Hazard Map (Drawing PE 9-1)
- Present Land Use Map (Drawing AG 2-6)
- Agro-Climatic Zones Map (Drawing AG 2-10)
- Impact of Agricultural Drought (Drawing AG 2-9)
- Water Resources and Irrigation Potentials (Drawing AG 3-1)
- Notes on Rainfed and Dry Farming (Chapters 3.2 and 3.3 of this Volume, and Technical Report No. 20).

If rainfed agriculture appeared to be possible, the choice of crops was mainly restricted by relevant soil characteristics, climatic conditions and sometimes local development objectives. Whenever applicable, priority has been given to locally preferred staple food crops like maize.

It was then attempted to determine the most feasible type of land use for each distinguished soil unit (see Soil Map, Drawing PE 5-1). In many cases a group of feasible crops have been indicated for a particular soil type, the final choice depending on the economics and local preferences.

A distinction has been made between "well" and "moderately" suitable for the different kinds of crops, for grazing and forest, dependent on the particular constraints encountered. For instance, if soils and climate are well suited for maize growing, but erosion hazard exists, maize was marked "moderately" suited in that particular case.

3.9.3 Potential Land Use Map

On Drawing AG 3-2, entitled "Potential Land Use", the physical boundaries of the identified types of land use are displayed.

In addition, land use types having similar characteristics were grouped together and classified according to their agricultural potential, with priority for food and cash crops.

The following 9 land use classes could be distinguished:

H.I **High Potential Mountain Areas**

Comprise mainly the more gently sloping parts of the Eastern and Western parts of the Usambara Mountains and the Nguru (or Kilindi) Mountains. Suited for tea, coffee, maize, vegetables and for forest.

H.II **High Potential Undulating Upland Areas**

Comprise exclusively the eastern and southern foot slopes of the Eastern Usambara Mountains and the eastern part of the undulating uplands. Suited for sisal, sunflower,maize,pulses and tree crops.

H.III **High Potential Irrigation Areas**

Comprise the Lower Mkomazi, Lower Pangani, Lwengera and Lukigura Valleys, Upper Umba Flood Plain, the Lower Msangasi Flood Plain and the tidal coconut irrigation area in the very Lower Pangani Valley. Suited for irrigated rice, mixed upland crops and vegetables.

M.I **Moderate Potential Undulating Upland Areas**

Comprise a large part of the Western Usambara Footslopes, eastern foothills of the Nguru Mountains and the well-drained, medium textured deep soils of the Coastal Plain. The areas receiving well distributed rainfall are suited for sisal, maize and pulse crops. The areas with lower rainfall and less favourable distribution are suited for sorghum, millet, pulses and forest.

M.II **Moderate Potential Lowland Areas**

Comprise the Msangasi Valleys, mbuga lands and some alluvial valleys along the Umba and Mbalamu river. Suited for combined irrigated and rainfed cropping of rice, maize and vegetables and for grazing if water resources are not sufficient.

L.I **Low Potential Mountain Areas**

Comprise the drier part of the Western Usambara Mountains (Malindi, Mlalo). Suited for sorghum, pulse crops, forest and occasionally tree crops.

L.II Low Potential Upland Areas

Comprise the central part of Handeni district, the sandy soils in the Coastal Plain, the northern footslopes of the Usambara Mountains (bordering the Umba Steppe) and part of Western Handeni. Suited for sorghum, millet, pulse crops and forest on the clay and loamy soil types receiving too low rainfall. Suited for cashewnuts, coconut and cassava on the sandy soil types, receiving adequate rainfall.

V.I Very Low Potential Areas

Comprise a large part of Handeni and the south of Pangani district, the outer mountain slopes of the Usambara Mountains, the steep mountain slopes of the Nguru Mountains and the northern part of the Muheza district (Coastal Plain). Suitability restricted to grazing and forest.

R No Agricultural Potential

Comprise most of the land north-east of the Usambara Mountains (Umba Steppe, partly Mkomazi Game Reserve) and the north-west part of Handeni district (actually known as Masaai Steppe, or Handeni controlled area). Not suited for any type of modern agriculture and may therefore be considered for Game Reserve, controlled area. Traditional grazing and game cropping may be envisaged as well.

4. POTENTIAL WATER DEMAND

4.1 SYNOPSIS

The assessment of potential water demand[1] both for irrigation and livestock is obligatory for the eleboration of a general water balance for the 1995 situation. Since potential water demand can exceed the available amount of water, the water balance yields a first impression of water deficits and surpluses in the demarcated catchment areas. Subsequently, potential water demand will have to be adjusted for the potential water resources and hence has a feedback impact on the final Water Master Plan.

4.2 IRRIGATION REQUIREMENT

4.2.1 Potential Irrigable Area

In order to compute the potential water demand for irrigation an assessment of the potential irrigable land has been given in Chapter 3.8. The assessment was based on the soil survey, field surveys of existing irrigation areas, previous studies and existing project proposals (see also Drawing AG 3-1). The potential or proposed projects are discussed in Chapter 3.8.

The net potential irrigable areas, which are shown overleaf (Table AG 4-1), are all rough estimates and have to be verified by detailed soil and topographical surveys. The selection of irrigated crops and crop patterns has been treated in Chapters 3.2 and 3.6.

4.2.2 Potential Irrigation Requirements by Sub-Catchment Area

Unit irrigation requirements which are discussed in Chapter 3.6 have been multiplied by the above-mentioned areas to obtain the potential water requirement per catchment area, an example of which is given in Table AG 4-4.

1) "Potential demand" means the most likely maximum water requirement, when constraints on water availability are disregarded.