SOMALI DEMOCRATIC REPUBLIC
STATE PLANNING COMMISSION

MOGAMBO IRRIGATION PROJECT

Supplementary Feasibility Study

ANNEX 3
Agriculture
ANNEX 4
Livestock

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MOGAMBO IRRIGATION PROJECT

SUPPLEMENTARY FEASIBILITY STUDY

This report comprises the following volumes:-

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ANNEX 3

AGRICULTURE

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CHAPTER 1

INTRODUCTION AND AGRICULTURAL BACKGROUND

1.1 Introduction

The agricultural planning for a State-owned large scale farm which will utilise effectively the physical and human resources of the Mogambo project area is discussed in this annex. The soils, population and labour force in the area are discussed fully in Annexes 2 and 6 respectively. The main conclusions regarding suitability of the land for irrigated cropping and availability of labour are mentioned here as they are primary factors determining the cropping and farming systems proposed.

The scope of the studies contained in this annex includes :-

(a) a brief review of present agriculture and agricultural projects in the Juba valley

(b) the selection of agronomically suitable crops and recommendations on their husbandry

(c) the preparation of cropping patterns which are technically feasible and which economically would exploit the potential of the area

(d) the determination of the most appropriate farming system with emphasis on defining the intensity of labour and machinery utilisation which should be employed

(e) the specification of the overall machinery requirements for the project and associated supporting and training services

(f) the estimation of requirements for storage of crops and for processing facilities

(g) the estimation of crop water requirements.

1.2 The Juba Valley

The potential for irrigated agriculture in the Juba valley has been tentatively put at 160 000 ha (State Planning Commission). Currently about 14 000 ha are being cultivated under controlled irrigation systems whilst a significantly larger area is being partly irrigated by uncontrolled flooding. In terms of area cultivated, however, rainfed farming is by far the most important. The bulk of the area is occupied by smallholdings of between 0.5 and 5 ha of cultivated crops with associated grazing areas.

Maize, sesame and sorghum are the major crops grown and are of almost equal importance amounting to between 32 000 and 35 000 ha of each crop in the Middle and Lower Juba regions. Table 1.1 shows the official estimates of area, production and average yields of annual crops grown in the Middle and Lower Juba in 1978. The data are indicative only and some figures may be inaccurate.

TABLE 1.1

Current Production in the Juba Valley

	Crops						
	Maize	Sesame	Rice	Ground-nuts	Vegetables	Cotton	Sorghum
Middle Juba							
Area ('000 ha)	18.3	18.1	1.8	0.3	0.6	0.3	16.1
Production ('000 t)	14.6	5.4	2.9	0.2	2.9	0.2	6.8
Average yield (t/ha)	0.8	0.3	1.6	0.7	5.0	0.7	0.4
Lower Juba							
Area ('000 ha)	14.7	19.6	0.5	0.3	0.1	1.4	16.7
Production ('000 t)	11.7	5.9	0.8	0.2	0.5	1.0	7.1
Average yield (t/ha)	0.8	0.3	1.7	0.7	5.0	0.7	0.4

Source: Ministry of Agriculture, 1979.

Although the cultivated area of bananas has fallen in recent years from 5 000 ha to 2 800 ha, bananas are currently the most important perennial crop in the Juba valley producing over 55 000 tonnes of export fruit annually. They are mainly a large scale crop and plantations are sited on the coarser textured levee soils. Yields are variable; the better plantations produce between 20 and 25 tonnes of exportable fruit per hectare although the overall average yield of exportable fruit is only around 10 tonnes (ENB, Jamama, 1979). Some 35% of the total production is not of exportable quality and is used for local consumption or is discarded.

Three significant agricultural projects have been planned and are being developed in the Lower Juba valley.

(a) Juba Sugar Project

The project is to be developed in two phases. The first phase will provide for the development of some 8 000 ha of sugar cane and should be completed by 1985. The second phase will add a further 5 000 ha of sugar cane bringing the anticipated output of raw sugar to around 100 000 tonnes per annum.

The initial plans for a surface irrigation system have been abandoned and an overhead sprinkler system is now being constructed. Although the change to a sprinkler system may mean a lower field irrigation requirement the project's demand during the January to April period will still jeopardise users downstream.

Development of the scheme started in 1977 and already some difficulty is being experienced in attracting adequate numbers of unskilled labour to the area.

(b) Fanoole State Farm

The Fanoole State Farm was started in 1974 and was planned to comprise an irrigable area of 8 300 ha. Completion was originally planned for 1981 but this cannot be achieved mainly due to the disruption caused by the departure of the Russian advisers and their replacement by Chinese. It is now quite likely that the original irrigation and proposed cropping patterns will be changed. The total area cleared to date is 2 500 ha of which approximately half is to be cropped in 1979. Up to 1 200 ha of maize, rice, beans, cowpeas and some fallow are planned for the gu season whilst about 1 000 ha of crops including cotton, maize, sesame, groundnuts and upland rice are planned for the der.

A number of difficulties are being experienced at present. These include the planned machinery inputs not being available, shortage of labour at planting, weeding and harvest, a high level of absenteeism in the labour force and frequent failure to obtain spare parts for the existing complement of farm machinery.

The yields being obtained are generally similar to the average levels shown in the official statistics.

(c) Trans-Juba Livestock Project (Annex 4)

The Trans-Juba livestock project started in 1974 and is scheduled for completion in 1979. It comprises two ranches extending over 300 km^2 and a feedlot of 300 ha. At full development, it should have a capacity to accommodate four batches of 3 000 to 3 500 head of cattle passing through the feedlot at three monthly intervals. It is expected that cattle of around 200 to 250 kg liveweight will make gains of 60 kg (0.65 to 0.67 kg/d) over the three month period.

Ranch grazing is to be supplemented by a forage ration of maize, lucerne, molasses and urea. Wastes from the feedlot will go via a lagoon and canal to the fields. The maize and lucerne fodder will be irrigated by surface methods, and yields of 5 and 4 tonnes of dry matter per hectare respectively are expected. It is assumed that bush clearance will reduce the existing tsetse fly populations to tolerable levels.

Other projects still in the preparation stage include Saakow, Mogambo, and the Homboy resettlement project.

1.3 The Project Area

1.3.1 Physical Resources

The soil mapping units for the area are based on the major geomorphic units described. Two major subdivisions have been recognised: the flood plain, basin clays developed on semi-recent alluvium and the old channel meander complex comprising soils developed on predominantly levee formations with smaller intervening depressions.

The basin clays occupy about 50% of the total soil survey area. These are deep heavy textured soils characterised by predominantly montmorillonitic 2 : 1

expanding lattice clays. Soil surfaces are moderate to strong gilgai formations. Structure is moderately well developed to 1 m but the subsoil is more massive and there is often a slight salinity hazard below this depth. However, much of this is accounted for by gypsum in the soils. These soils are suitable for both rice and upland crops, the degree of gilgai formation normally being the main constraint to development.

The old channel meander complex occupies 38% of the survey area. This is subdivided into soils developed mainly on levee formations (27%) and soils of broad flat depressions (11%).

Soils of the levee sub-unit are often stratified with variable textures ranging from silt clay loam to loams and very fine sandy loams. Structures and carbonate distribution within the profile are often a reflection of depositional sequence rather than pedogenesis. Large numbers of termitaria are developed within these areas, many containing active termite colonies. These will act as a considerable topographic restraint to development and most of these soils have been recommended for sprinkler irrigation. Salinity levels are low except below 1 m where some values exceed 4 mmhos/cm. The depression sub-unit of the meander complex is marked by the development of clay loam and clay soils often overlying sandy horizons and lenses within 2 m of the surface. These soils have many characteristics in common with the basin clays of the flood plain though gilgai formations are rarely as strongly developed. Salinity levels are low but there is a slight flood hazard in the more low lying areas. In terms of future cropping and land use potential, they are similar to the basin clays.

The remaining 12% of the study area is composed of small depressions, often permanently flooded, terraces, and soils developed on aeolian and marine alluvial deposits. These areas have little potential for development within the existing irrigation proposals.

1.3.2 Water

The hydrology of the area is described in Annex 1. The Juba river is the main source of irrigation water. The high flows generally start in late April and end in mid-January, falling from at least 150 Mm^3 per month throughout the period May to December, to a low level of 15 to 25 Mm^3 after January. Although the specific conductivity of the water rises during the low flows periods to 1 mmho/cm, the water quality is generally good. Peak conductivity values can be as high as 4 mmhos/cm but these rarely last for more than one week and occur usually with the first flush of water in the river following the start of the rainy season.

The available information on groundwater in the Lower Juba valley is very limited. Villages within the project area depend on shallow wells for domestic water, and in the Trans-Juba livestock project there are two 80 m deep tubewells. Water quality is generally poor and in the absence of better estimates of its likely extent, groundwater cannot be considered as a potential source of irrigation water.

Without storage on the Juba, the low flows between mid-January and late April will limit the cropping period in the project area to about 260 days between mid-April and the end of January and will effectively preclude cultivation of perennial crops. However, construction of the Bardheere dam, scheduled for the latter half of the 1980s, would relieve the water constraint between February and April and allow perennial crops to be included if economically and technically justifiable.

1.3.3 Climate

The climate is tropical semi-arid with a mean annual precipitation of around 430 mm which falls mainly during the gu (April-May/June) and der (September/October-December) season. The gu season rainfall is higher and more reliable than the der, normally ranging between 250 and 300 mm. May and June are the two months of heaviest rainfall and are characterised by heavy storms with intensities sometimes in excess of 75 mm/h rather than uniform precipitation. The der season rains range around 150 mm and again are characterised by heavy storms. The haggai season falling between the gu and der seasons is an intermediate rainy season with decreasing precipitation falling as a mixture of showers and isolated storms. It is characterised by cooler cloudier weather. The gilal season (January-March) represents the main dry season with the total precipitation during the three months rarely exceeding 10 mm. Although the four seasons are distinct, annual variations in the sequential change between them are such that there is a large degree of unpredictability in the start, duration, and total precipitation of each season.

Temperatures range between 22°C (mean monthly minimum) and 31°C (mean monthly maximum) with a monthly average of between 25°C and 28°C and an annual average of 26°C.

1.3.4 Present Agriculture

There are between 1 500 and 2 000 farm holdings within the 9 500 ha of the Mogambo study area. These vary in size from 0.5 to 4.5 ha, though most holdings are about 1 ha in size. Holdings are rarely held in compact blocks and farmers may cultivate land in a number of areas on a variety of soil types. Some farmers even take up temporary residence away from their village for the duration of the cropping season.

Land tenure is established in a number of ways, the most common being land clearance for which no permission is necessary. Such land is often passed on by inheritance. Some land is obtained by outright purchase though this method is limited mainly to areas adjacent to the village and to immigrant populations. Land is occasionally lent to relatives or rented to others.

Disputes over land ownership are rare and are usually limited to areas of land in the fartas as the flood water recedes. The concept of State ownership of the land has been generally accepted. Dispossessed occupants do expect to be offered an alternative site and/or the opportunity of employment on the project.

Mechanisation is confined largely to land preparation by tractor using ploughs and/or disc harrows. This service was provided by ONAT at subsidised rates, but increasing mechanical problems and a diminishing service have stimulated the growth of private tractor hire services.

Maize is the main crop in the gu season. Planting takes place in April and harvesting in July and August. Some cotton is also planted in the gu season. Sesame is the main der season crop together with some maize and sorghum. These crops are usually dry planted in anticipation of the der season rains in October and November. Beans are frequently interplanted with these crops in both seasons. Supplementary crops include yams, tomatoes, cassava, sugar cane, paw paws, and tobacco.

Primary cultivation is rarely practised. Land preparation is confined to small basins, prepared by hand with a yambo, in which seeds are planted. Small areas are prepared by mechanical equipment. Only local varieties of non-improved types are grown, no fertilisers are used and although harvesting by hand is reasonably efficient, shattering of the sesame occurs resulting in considerable losses at harvest time.

Apart from the hazards associated with either excessive or inadequate rains, stem borer in cereals and the bird **Quelea quelea** are the most serious pests.

Only small number of sheep and goats are herded by the settled population but for almost half the year cattle owned by the nomads graze the area. This causes no conflict of interest at present.

While yields vary from year to year and place to place very few reliable statistical data are available. The Inter-riverine agricultural study (HTS, 1977) suggested an average yield of sorghum of 300 kg/ha. In the FAO report 'Somalia - water use. A country brief', sorghum yields are estimated at 300 to 500 kg/ha, and maize 400 kg/ha. Sesame yields of around 200 kg/ha are also reported.

1.4 Crop Processing

A cotton ginnery is currently in operation at Jamama whilst facilities for maize drying and rice hulling are being erected at Jamama and Gelib respectively.

1.4.1 Cotton Processing

The cotton ginnery at Jamama which was previously controlled by the Agricultural Development Corporation (ADC) was taken over by Somaltex in 1979. With cotton production being extended by 2 000 ha in the Jamama area, 600 ha at Gelib and by a significant area in the Mogambo project, the existing ginnery, even if reconditioned, could not possibly handle the entire crop. The ginnery has 26 single roller Platt gins some of which are over 60 years old. Each gin has a capacity of 40 kg/h which with two 8 hour shifts per day and 250 days ginning per year gives a theoretical capacity of 4 000 tonnes of raw cotton. Assuming a ginning efficiency of about 60%, some 2 500 tonnes of raw cotton could be processed in one year. This is considerably less than the capacity which will be required when the developments above are completed. Somaltex therefore is considering three options :-

(a) to recondition the existing plant and extend the present storage capacity of 32 000 m^3 to meet the interim production needs

(b) to install a completely new plant and to extend the storage capacity

(c) to establish a new ginnery more conveniently located to the proposed cotton developments and to use the existing buildings at Jamama for buffer storage.

1.4.2 Maize Drying

Maize will almost certainly require to be dried artificially if harvested in the haggai season. Drying is probably not necessary for der maize harvested in the gilal season. Seven standard Bentall model 1 CV 240 m driers including cob sheller units, have already been purchased. Two are being assembled in the south Juba region, one at the ginnery compound in Jamama and the other at Gelib. The others are being established at Shabelle and Afgoi. The throughput for driers, assuming a moisture reduction of 7% from 21% to 14%, will be in the region of 6 to 7 t/h.

1.4.3 Rice Hulling

The ADC currently operates a number of hulling mills and requires rice to be at a moisture content of around 12% before hulling. These mills are of a standard manufacture and were supplied by Columbine of Milan. The mill planned for Gelib has a 1 t/h throughput. The composition of the output is expected to be about 70% including 15% broken grains. Since no other hulling plants are planned for the Lower Juba, the Mogambo project will have to meet its own requirements for drying and hulling.

1.5 Agricultural Services

A detailed description of the agricultural services and institutions operating in the region is given in Annex 6. In this section a broad outline of the services available is given to provide the background to the succeding chapters. The major organisations involved are the Ministry of Agriculture, the National Farm Machinery and Agricultural Supply Service (ONAT), the Agricultural Development Corporation (ADC), the Trade Agency for Vehicles and Spares (WAGAD) and Somaltex.

1.5.1 The Ministry of Agriculture

The Ministry of Agriculture has a regional office at Kismayo comprising four functional departments: administration, plant protection, land and water extension (includes research), and co-operatives.

1.5.2 The National Farm Machinery and Agricultural Supply Service (ONAT)

ONAT has workshop facilities and a machinery hire service based at Jamama and Gelib. The Jamama station has a total of 45 tractors (25 crawlers of 75 to 110 hp and 20 wheeled tractors of 50 to 90 hp) whilst at Gelib there are 20 tractors (10 crawlers and 10 wheeled). The hire charges are highly subsidised with different rates for Government and private use. The hourly rates are as follows:-

	Government (SoSh/h)	Private (SoSh/h)
Crawler 110 hp	95	50
Crawler 75 hp	57	36
Wheeled tractor 50 to 90 hp	42	25

They are employed mainly for land preparation and the same rate is used whether for disc harrowing or ploughing.

1.5.3 Trade Agency for Vehicles and Spares (WAGAD)

WAGAD was established to co-ordinate the purchase of agricultural machinery and supporting services such as equipping workshops.

1.5.4 The Agricultural Development Corporation (ADC)

The ADC is a semi-autonomous agency responsible to the Ministry of Agriculture. It was established in 1971 to co-ordinate the purchasing, storage, handling and marketing of all domestic grains. Its purchases cover maize, sorghum, rice, sunflower, sesame, groundnuts and cotton.

CHAPTER 2

CROP SELECTION AND CROPPING PATTERNS

2.1 Crop Selection

Given the soil and climatic conditions of the project area and the availability of irrigation water, a wide range of crops can be grown. The suitability of particular crops is influenced by the seasons (principally the gu and der seasons) and by the two main soil types, the basin clays and the levee soils. Table 2.1 shows the range of annual crops suited to the area by season and soil type. Although the levee soils in the der season would allow the widest range of crops, neither soils nor season represent major constraints to the range of crops that can be grown. Without the construction of the Bardheere dam only annual crops can be comtemplated. Should Bardheere be constructed as is anticipated in the latter part of the 1980s, the range of possible crops would be extended to include bananas, citrus and sugar cane. Of these only sugar cane could be cultivated on the basin clays whilst all three could be cultivated on the levees. Sugar cane cultivation, however, could not be undertaken independently of the Juba Sugar project which would have to have adequate milling capacity to handle Mogambo cane. Since the present plans for the Juba Sugar project anticipate about 13 000 ha of cane, the prospect of growing cane at Mogambo for the Juba Sugar project mill is unlikely. However this could be reconsidered following the construction of Bardheere dam.

The initial selection of crops from this wide range has taken into account the need to maximise benefits by the inclusion of the high value crops, the need to reduce national imports of basic commodities (grains, vegetable oils and textiles), and the need to include crops which will complement each other by utilising labour and equipment effectively throughout the year. Lastly the number of crops selected has deliberately been kept to the minimum in order to simplify the farming system and to reduce the complexity of the managerial task. The annual crops selected for inclusion in cropping patterns are rice, maize and cotton. Of the perennial crops possible after the construction of the Bardheere dam only bananas are selected.

TABLE 2.1

Annual Crops Suited to Cultivation at Mogambo

Gu season		Der season	
Basin clay	Levee soils	Basin clay	Levee soils
Rice	Rice	Rice	Tobacco
Maize	Maize	Sesame	Groundnuts
Sunflower	Sunflower	Maize	Cotton
Pulses	Pulses	Cotton	Sesame
Sorghum	Sorghum	Sunflower	Maize
	Cassava	Pulses	Castor
		Tomatoes	Safflower
			Pulses
			Tomatoes

2.1.1 Selected Crops

(a) Rice

The basin clays are particularly well suited to the cultivation of paddy rice. Construction of basins will not involve excessive land levelling, and the slow draining characteristic of the soil will minimise losses to deep percolation. Rice yields from a basin system are generally higher than under upland conditions and maintenance of weed control is considerably easier. Rice is potentially the most profitable of the annual crops and is a major import commodity. Upland rice can be grown on the levee soils but this crop will have to be rotated to avoid problems associated with weed growth.

(b) Maize

Maize is currently grown successfully on both the basin clay and levee soils. Although a lower value crop than rice, it is a major commodity and is a staple food of Somalia. The availability of short season composite varieties which allow double cropping makes it a crop suitable for an intensive system of irrigated farming. An added advantage is its compatibility wth rice in terms of utilisation of machinery and equipment.

(c) Cotton

Although the history of cotton production in Somalia has been marred by indifferent management on some schemes, it is regarded as having considerable potential. Where management has been effective in controlling pests, high yields of up to 30 quintals of seed cotton per hectare have been achieved. Compared with other annuals it is a high value crop and is a major national import. The main disadvantages are its requirement for highly skilled management to control pests and its peak labour demand at picking. The latter may eventually be avoided, however, if a successful system of mechanised harvesting can be introduced.

(d) Bananas

Bananas are the only perennial crop selected. They are a high value and important export crop for which considerable experience in production and marketing has already been built up in Somalia. They are only included, however, where the construction of the Bardheere dam is assumed.

2.1.2 Excluded Crops

The annual crops not included are sesame, sorghum, groundnuts, sunflower, castor, safflower, tobacco, pulses and vegetables. Sesame is well suited for inclusion in the cropping pattern as it is a short season crop allowing flexibility in planning. In addition sesame oil is very popular locally and vegetable oils are a major import commodity. However the crop budget (Annex 7) indicated that sesame has very low returns and therefore its inclusion in the project crops could not be justified.

Sorghum was excluded because of its relatively low returns and the present state of almost self-sufficiency in production. Groundnuts were also excluded because of their relatively low returns which do not justify the highly skilled management required at harvest and because of the risk of **Aspergillus flavus.** Sunflower, safflower and castor were rejected because of the limited knowledge on production of these crops in Somalia. Although tobacco could be grown, the heavy soils throughout the area are not well suited to the production of the flue cured leaf and thus the managerial requirements of an inherently technically demanding crop would be even greater. There is also a shortage of fuel for flue curing and lack of agronomic data on cultivation of the crop in Somalia. Pulses and vegetables were considered to be better suited to small scale production and are not recommended for inclusion in the cropping patterns.

2.2 Crop Agronomy

In this section recommendations are made on the agronomic practices to be followed in the cultivation of the crops. In particular, varieties, times of planting, seed bed requirements, seed rates, fertiliser policy and pest and disease control are discussed. Apart from primary cultivations and land preparation prior to planting, mechanisation of operations is not discussed in detail. This is done in Chapter 3 where the implications of opting for a more labour intensive or a more machine intensive system are considered and in Chapter 4 where the annual requirement for machinery is specified.

2.2.1 Rice

Paddy rice is well suited to cultivation on the clay soils and has marked advantages over upland rice in terms of yield potential and ease of weed control.

Upland rice is a potential crop for the levee soils but will be more demanding on management. Its importance in the cropping pattern should be based on the need to allow rotation with other crops.

The cultural practices recommended for paddy and upland rice are generally similar but where marked differences occur they are noted in the following sections.

(a) Varieties

A comprehensive range of rice varieties is currently being tried at Afgoi and it is expected that, within a few years, additional stocks of pure seeds should become available. The main varieties currently available are Dawn, Saturn, Vista, Kendo and Shendo. Vista is a 105 day variety and has outyielded Dawn and Saturn in trials at Afgoi. Kendo and Shendo are both 120 day varieties and are recommended by the Chinese Technical Team. They have similar yield potential but Shendo is more prone to shattering. Since Vista is physiologically adapted to paddy and upland conditions, and is a high yielder with the added advantage of being an early maturing variety, it is recommended as the main variety for the project. Kendo, which is less prone to shattering than Shendo, could also be grown if flexibility for spreading the harvesting season is required.

(b) Land Preparation

Primary cultivations should comprise an initial chisel ripping followed by a heavy disc harrowing. For paddy rice the seed bed would be prepared by land planing to level and consolidate the soil profile and by final shallow discing. Land planing would not be necessary with upland rice.

(c) Seed Rate and Planting

In both systems, between 100 and 120 kg of seed per hectare would be required. It should be combine drilled using a 30 row drill with a standard 174 mm row spacing. A mounted 'trembler' type harrow would ensure cover of the seed.

Although there is conflicting evidence on the season when bird damage is likely to be greatest, it is considered that, on balance, gu planting with harvest before the middle of September is likely to involve least damage. Consequently planting as soon as possible in April or early May is recommended as birds become an increasing problem from mid-July onwards. Flexibility will, however, be provided within the cropping patterns proposed by combining gu rice with a der crop such as maize which is not affected by birds and which can be grown in either season. Thus, if necessary, rice and the maize crops could be interchanged.

(d) Fertiliser

Ideally, fertiliser recommendations should be based on trials carried out in the project area. Since these are not available, recommendations are based on rice growing at Fanoole state farm and at Afgoi and on the knowledge that rice generally responds to fairly high levels of nitrogen and phosphate. It is anticipated therefore that up to 150 kg/ha of nitrogen and 30 kg of P_2O_5 would be justified. The nitrogen should be applied in the form of urea in two applications: 100 kg by spinner broad-caster before, and 50 kg at, tillering. The P_2O_5 would be combine drilled at planting.

(e) Weed Control

Herbicides represent the most effective means of weed control. Post-emergence applications of a combination of Preforan (30 EC at 8.9 l/ha) and Propanil (36 EC at 1.5 to 2.0 l/ha) about 12 days after crop emergence are recommended for both upland and paddy rice. Weed control for the latter would be maintained by the flooding of paddies and spot applications of herbicides where necessary. Upland rice would require an additional herbicide spray and additional spot spraying and hand weeding.

(f) Pests and Diseases

The major problems are likely to be associated with rice stem borer (**Chilo partellus**) and birds (mainly **Quelea quelea**).

Rice Stem Borer

This can be effectively controlled by ULV sprays of Dimecron 250 at 2.5 to 3.0 l/ha. The first application would be around the fourth week after planting and further applications would be at three weekly intervals if required. With exceptionally high infestations Carbofuran would be used for the first application.

Quelea quelea

Bird scarers have only limited effectiveness in preventing damage by birds. The most appropriate course is to avoid damage by planting early so that harvest does not coincide with high bird population. Use of avicides is possible but their use would have to be part of a national programme if any significant measure of protection is to be achieved.

Rice diseases are of little significance in Somalia at present and, apart from the maintenance of rigorous standards of crop hygiene, no specific measures can be recommended.

(g) Harvesting

Irrigation applications will cease about 3 to 4 weeks prior to harvest to enable ground conditions to dry out sufficiently to permit combine harvesting. Combine harvesting is regarded as the most appropriate means of harvesting the crop since it is imperative that harvesting is accomplished rapidly to avoid bird damage, reduce shattering losses and to allow more time for land preparation for the succeeding crop. The rice would be cleaned, dried, hulled and graded in the period following harvest.

(h) Yields

Paddy rice yields are generally higher than upland. At the Haawaay farm, average yields of 30 quintals/ha have been achieved in successive years whilst at Jowhar experimental farm yields of up to 50 quintals/ha have been achieved from a 40 ha field. It is considered possible therefore for average yields of 40 quintals/ha to be achieved under paddy conditions and 35 quintals/ha under upland. Since time will be required for management to settle in, and for the effects of soil disturbance during land clearing and forming operations to be overcome, the yields will be expected to build up over a period of time as follows:-

	Year			
	1	2	3	4 onwards
	quintals/ha			
Paddy rice	25	30	35	40
Upland rice	20	25	30	35

2.2.2 Maize

Maize will provide some flexibility in formulating cropping patterns; it can be grown on either the basin clay or levee soils and although it is expected to yield better in the der season can also be grown successfully in the gu.

(a) Varieties

Varietal research is currently being carried out at Afgoi. A number of local varieties and a recently developed Somali composite variety are currently available. The composite far outyields the local varieties and, although it is less acceptable for local consumption because it is yellow seeded, it is the variety recommended for immediate production on the scheme. It is short statured, matures within 105 dyas and is easily double-cropped. In the longer term, however, it is recommended that every effort should be made to develop a white-seeded composite which would be preferred for local consumption.

Hybrid varieties are not recommended at this stage because of the additional organisation that would be required for the production of replacement seed stocks.

(b) Land Preparation

Primary tillage would be mainly carried out by a 'soil-saver' plough/time unit which is designed specifically for incorporating stubble or trash from a preceding crop. This operation would be particularly important where maize is double-cropped with rice. Secondary tillage would comprise disc harrowing for final seed bed preparation. Land planing would be unnecessary and planting would be on the flat.

(c) Planting and Seed Rate

Planting in the gu season should coincide with the onset of the rains (normally mid-April) and would be completed by the end of May. Later planting could lead to a higher incidence of stalk borer and limit the potential for double-cropping. Der season planting should be limited to the period between September and mid-October. Gu maize would be harvested in early August and der maize in late December and early January.

Planting would be by combine drill modified by 'blanking-off' intermediate rows to achieve six row planting. Seed would be covered by a mounted 'trembler' harrow. About 20 kg of seed per hectare dressed Fernasan D would be required. The proposed spacing should give a plant population of around 45 000 plants per hectare.

(d) Fertiliser

Again, without specific trials in the project area it is difficult to make precise recommendations on the levels which should be applied. However, the following estimate is probably a reasonable indicator of the level which would be economically worthwhile and extend the yield potential in the area:-

(i) 50 kg of nitrogen per hectare applied by spinner broadcaster before discing.

(ii) 25 kg of P_2O_5 per hectare combine drilled with the seed at planting.

(iii) a side dressing of 60 kg of nitrogen per hectare when the crop has reached knee height. Using tool bar equipment this operation can be carried out simultaneously with inter-row cultivation and tilling up.

(e) Weed Control

A post-emergent application of Primagram 500 FW at 5 l/ha applied just before the first irrigation is recommended. Spot applications of herbicide combined with rolling tine cultivations would be used later in the season if necessary.

(f) Pest and Diseases Control

The most serious pest likely to be encountered is the stem borer (**Chilo partellus**). Effective control can be achieved by applying two sprays of Nuvacron Combi (Monocrotophos/DDT) at 10 and 20 days after planting, 5 l/ha total application. Cutworms can occasionally cause serious damage. Furadan (Carbofuran) granules mixed with the seed (1 kg active ingredient per 100 kg of seed) will provide adequate control.

Maize is generally free from any significant diseases. However, the crop should be inspected regularly for signs of leaf blight (**Helminthosporium turcicum**). Sound crop hygiene will reduce the likelihood of re-infection from crop residues.

(g) Harvesting

Mechanical harvesting by combine harvester is proposed. The rice harvesting units can be adapted by fitting maize harvesting attachments to cope with the crop. Gu season maize harvested in the haggai season will probably have to be dried artificially. This can be done in a dual purpose rice/maize drier. The Jamama plant could be used occasionally when seed moisture is too high.

(h) Yields

The introduction of irrigation and use of the recommended practices above, should lead to considerably higher yields than the current levels being achieved by smallholders in the area. Twenty to twenty-five quintals of maize per hectare have been achieved on the field scale at the FAO pilot project farm whilst up to 70 quintals/ha have been achieved under experimental conditions. Overall there is sufficient evidence within Somalia and from neighbouring countries to indicate that yields of up to 40 quintals/ha can be achieved on the large scale with composite varieties. Allowing for the recovery of soil after soil disturbance during land clearing and for management to build up experience, the following yields are projected.

	Year			
	1	2	3	4 onwards
Quintals/ha	25	30	35	40

2.2.3 Sesame

As was mentioned in Section 2.1, sesame has been excluded from the cropping pattern. Details of its cultivation are included here since they are required to develop the crop budgets presented in Annex 7.

Although sesame is intolerant to waterlogged conditions it can be grown on both the basin clay and levee soils. With the former, however, particular care would have to be taken with land levelling and with irrigation applications. Sesame is a der season only crop.

(a) Varieties

To date little varietal selection or research has been carried out with sesame. Some introductions, mainly from Egypt, have been tried but these have compared poorly with the local varieties. A recently discovered indigenous variety with an 8 locule capsule and white seed shows some promise of higher yields than the current local variety.

However, until it has been systematically tested and is more readily available, the current local varieties will have to be used.

(b) Land Preparation

The primary cultivations recommended are similar to those for maize (Section 2.2.2 (b)). Secondary tillage would comprise disc harrowing followed by land planing and a final discing to complete the seed bed preparation.

(c) Planting

Sesame should be planted between mid-September and October allowing flowering to take place after the der rains and thereby maximising pod set. Planting would be by combine drill with the appropriate intermediate rows blanked off and a mounted 'trembler' tine harrow to ensure soil cover. Pelleted seed should be used and, if obtainable, about 6 kg/ha will be required. Otherwise 8 to 10 kg of non-pelleted seed will be required.

(d) Fertiliser

Sesame response to fertilisers is variable and trials on site are necessary before precise levels of fertiliser can be recommended. It is anticipated, however, that 50 kg of N and 25 kg of P_2O_5 per hectare are a reasonable indicator of the fertiliser levels which should be applied.

(e) Weed Control

Chemical weed control comprising one application of a pre-emergent herbicide, Treflan, at 2.8 l/ha incorporated by shallow discing is recommended. The row spacing recommended above (Section 2.2.3 (c)) should lead to an early canopy closure and minimise the need for spot weeding.

(f) Pests and Diseases

Little damage is usually done by pests. Gall midge (**Asphondylia sesami**) and the caterpillar (**Antigastria catalaunalis**) are the most likely pests but these can be controlled using Basodin EC (1.5 to 3.0 l/ha) and Nogos (1 l/ha).

Diseases are of little significance.

(g) Harvesting

Until a suitable sesame harvesting front for a standard combine harvester has been tried and demonstrated successfully, hand harvesting is the only practical alternative. Work on mechanical harvesting is currently going on in the Sudan. The application of a dessicant about one week before harvest may have a 'fixing' effect on the sesame and lead to a reduction in losses by shattering.

Drying should not be necessary since the crop will be harvested in the gilal season. Sesame stems make good kindling for fires and it is likely that chopping will be unncessary as the bulk of the material will be cleared by villagers.

(h) Yields

Some of the better farmers claim yields of 6 to 8 quintals/ha. Under research conditions at Afgoi, yields of betwen 7 and 8 quintals/ha have been obtained. The project yields obtained on the FAO pilot project exceeded 8 quintals/ha. If recommended practices are followed it is considered that the yield potential of the local variety is fairly high and the following yield build up could be expected.

	Year			
	1	2	3	4 onwards
Sesame (quintals/ha)	4	6	7	8

2.2.4 Conventional Wide-row Cotton

Because cotton has an extremely high peak demand for labour for two months at picking, alternative systems of cotton cultivation which did not have such marked peaks in the labour requirement were considered. Investigations focussed mainly on systems which included mechanisation of the harvesting operation. The main conclusion was that at this stage there is no well tried mechanised system which is ideally suited to irrigated conditions in Somalia and which could be recommended for immediate implementation. One system, however, which has recently been introduced into the Sudan and is practised under rainfed conditions has possibilities but before it can be recommended for inclusion in an intensive irrigated farming system in the Lower Juba (where maximising yields is imperative), it will probably require a considerable period of trial and modification. The system is discussed in Section 2.2.5.

This section is confined to a discussion of the conventional 'wide-row' system of cotton production with hand picking which is currently practised in Somalia (at Balcad, Afgoi, Mordile and the FAO pilot project farm) and in neighbouring Ethiopia and Kenya.

Cotton would be confined to the levee soils and would be grown under overhead irrigation.

(a) Varieties

Medium staple varieties of staple length $1^1/_{32}$ in. to $1^1/_{16}$ in. are the most suitable for Somali conditions and meet the requirements of the Somaltex textile factory. Acala 5.51, Acala 4.42 and recently Barac have been grown at Balcad. Both 4.42 and Barac have shown promise and are recommended. The latter is black-arm resistant Acala with the characteristic of storm proof bolls.

(b) Land Preparation

Primary cultivations would comprise chisel ripping to a depth of about 30 cm which would be followed by disc harrowing. Since the area would be irrigated by overhead sprinklers, neither land planing nor ridging are considered necessary, except that all fields will be land planed after bush clearance and removal of termitaria (Annex 5, Chapter 3).

(c) Planting

Cotton should be planted in the der season and timed so that boll opening coincides with the end of the rains and onset of dry weather. Since first boll opening occurs between 110 and 115 days after planting, planting should be completed in August or early September. Picking would commence in mid-December after the der rains and should be completed before the end of February.

Planting should be in rows 75 cm apart with 20 cm spacing within the row, giving a population of around 65 000 plants per hectare. About 10 to 12 kg of acid delinted or 30 kg of undelinted seed dressed with Fernasan D would be required. Planting would be by combine seed drill with intermediate rows blanked off.

(d) Fertilisers

Fertiliser applications should be in the order of 25 kg of P_2O_5 and 80 kg of N per hectare. Since there is no specific information on cotton responses to fertiliser in the project area, this is based on the level required to replace nutrients taken up by a 25 quintal/ha crop of seed cotton. It is also in line with fertiliser policies for high yielding cotton elsewhere. The phosphate would be applied at planting and the urea by spinner broad casting immediately before the final disc harrowing.

(e) Weed Control

A combination of herbicides, mechanical weeding and spot weeding by hand is recommended. Early control would be achieved by application of a pre-emergent herbicide, Treflan at 2.8 l/ha which would be incorporated into the soil by the final discing prior to planting. This would be followed later by a mechanical cultivation with a rolling tine harrow and ultimately by spot weeding where necessary.

(f) Pests and Diseases

The main cotton pests at the Afgoi and Balcad schemes are the boll worms, American (**Heliothis armigera**) and spiny (**Erias** spp.), various leaf eaters, jassids, aphids and cotton stainers (**Dysdercus**). The attacks by pests are usually of high intensity and the most effective means of control has been systematic blanket spraying at 8 to 10 day intervals from first bud formation (about 40 days after planting) through to about 120 to 130 days. ULV sprays at a rate of 2.5 l/ha of Nuvacron Combi (Monocrotophos/DDT) are recommended. This has been tried at the FAO pilot project and has been shown to provide effective control. No serious diseases are expected.

(g) Harvesting

The crop would be hand picked in either two or three picks. Picking would commence in late December and continue to the end of February. There is likely to be some clearance of cotton stalks by villagers collecting them for fuel. The remainder would be chopped by a flail chopper and buried by a 'soil saver' unit.

(h) Yields

There is very little information available on the performance of well managed cotton on the field scale in Somalia. The existing information indicates widely ranging yields and usually reflects poor pest control and indifferent management. The nearest crop was at the Fanoole state farm where an estimated yield of 5 quintals/ha of poor seed cotton was obtained. About 10 quintals/ha are being achieved at the seed multiplication farm at Afgoi. With good management the yield potential is higher; trials between 1966 and 1975 gave yields of over 30 quintals/ha (CARS, 1966; FAO, 1975) and at the FAO pilot project it is considered that average yields of 25 quintals/ha of seed cotton should be obtainable.

The expected build up in yields is as follows:-

	Year			
	1	2	3	4 onwards
Seed cotton (quintals/ha)	12	16	20	25

2.2.5 Narrow-row Stripper Picked Cotton

Although mechanical harvesting of cotton has not yet been introduced into Somalia, various systems of machine picked cotton production were considered, mainly because the shortage of casual labour (Annex 6 of this report) could effectively limit the total area of cotton planted. Since cotton is potentially a relatively high value crop in comparison with maize or sesame, every possibility of maximising the area under cotton was examined. Narrow-row stripper picked cotton (currently being used under rainfed conditions in the Sudan) is regarded as being the most likely system to be successfully adapted to irrigated conditions in Somalia. The cotton stripper is a much more robust and less sophisticated machine than the spindle pickers and requires considerably less skilled maintenance whilst in operation. The main disadvantage is that as the entire boll is stripped from the plant, the cotton requires an additional cleaning facility at the ginnery. The main features of the system are as follows:

(a) A variety with a storm proof boll such as Barac would be grown and it should be a variety of as short a stature as possible.

(b) It would be planted in narrow rows, 460 mm aprt at a spacing of 43 mm within the row, giving a population of around 500 000 plants per hectare. Planting could be by combine drill with the required row spacing being achieved by blanking off intermediate spouts. Up to 50 kg of acid delinted seed per hectare would be required.

(c) The system is dependent on short statured plants of preferably no more than 60 cm height to enable efficient harvesting. This can be achieved by a combination of variety, high plant populations and a fertiliser policy which limits the application of nitrogen. There is the danger, however, that limiting the nutrient supply will prevent yields reaching the level necessary to justify irrigation.

(d) Weed control would be achieved by pre-emergent herbicide application and would probably be more easily maintained since full canopy is likely to be reached earlier with the high plant population.

(e) The methods of pest and disease control would be similar to those used in conventional hand picked cotton.

(f) Harvesting would be a 'once over' operation. Desiccation of the plant would be carried out by the application of Reglone about 10 days prior to harvest. Althouth the use of a leaf desiccant will reduce the trash in the harvested cotton, additional cleaning will be required before ginning.

(g) The estimated yields are as follows:

	Year 1	2	3	4 onwards
Seed cotton (quintals/ha)	10	15	20	20

It is concluded that potential for introducing this system should be carefully examined in a comprehensive research programme carried out on the field scale (up to 100 ha). The initial emphasis would be on finding the most suitable variety, and establishing the husbandry techniques which would produce a plant size which can be handled by the stripper harvester. This would be followed by a full scale evaluation, particularly of yield potential and an eventual decision as to whether the system should be introduced on the large scale.

2.2.6 Bananas

The construction of Bardheere dam in the latter part of the 1980s will remove the water constraint which currently precludes the cultivation of perennial crops. Bananas are the main perennial crop for which there is a potential for production in Mogambo. As they grow best on deep friable well drained soils they should be confined to the levee soils. With reasonable management the life of the plant could be up to six years.

(a) Varieties and Planting Material

Until new varieties have been evaluated there is little evidence against the continued cultivation of Poyo. However, research is needed to assess dwarf varieties in order to lessen problems caused by high winds. Also, fresh planting material is required in order to maximise the benefits of introducing improved nematode control. Material for multiplication could be introduced through a plant quarantine service.

(b) Land Preparation and Planting

The main function of the land preparation operations is weed control. They would comprise chisel ripping and deep ploughing immediately after removal of the old stumps which would be followed by a fallow period of 3 to 6 months depending upon the time of the year and the timing of planting the new crop. Immediately prior to planting the land would be ploughed and disc harrowed.

Planting would follow standard practices (selection of suitable material and trimming of dead and diseased parts) and would aim to provide about 2 000 plants per hectare. The suckers would be planted on the flat in rows of between 2 and 3.65 m apart and 1.5 to 2.2 m between the plants.

(c) Weed Control

Weed control during the first year of growth involves a high labour input. In order to obtain good weed control and avoid the problem of labour shortage, the use of herbicides is recommended. Current recommendations are:

(i) Gesapax (ametryne) at 4 l/ha at planting.

(ii) Gesapax/Gepiron at 8 l/ha at three months after planting.

(iii) Gesapax/Gepiron at 4 l/ha at six months after planting.

This will enable good control of weeds until full crop cover is reached at nine to ten months after planting, after which only light weeding is required.

(d) Nematode and Banana Weevil Control

The following recommendations using granular formulations of the nematocide/insecticide Furadan (Carbofuran) are recommended:-

(i) First year - 20 g/plant of Furadan 10G at planting and every four months.

(ii) Second and following years - 30 g/plant of Furadan 10G every six months.

Assuming 2 000 plants per hectare, this represents 120 kg/ha per year of Furadan 10G. This will replace Nemagon (DBCP) with a safer and easily applied nematocide which has effectively controlled nematodes in other banana producing countries. The improved nematode control will probably extend the average life of banana plantains to six years from the present average of around three years. The use of Furadan will also control the moderate infestations of banana weevil. No other pest or disease control measures are required.

(e) Fertilisers

No proper fertiliser trials have been undertaken by CARS or ENB and little information is available beyond a known response to nitrogen. Based on estimated nutrient uptake by bananas at expected yields of 250 to 300 quintals/ha/year and the fact that bananas are heavy nitrogen and potassium feeders, provisional recommendations are as follows:-

	quintals/ha/year
Urea	6
DAP	1
Potassium sulphate	2

This will proivde 296 kg/ha N, 50 kg/ha P_2O_5 and 100 kg/ha K_2O. Estimated K applications are moderate because most potassium is returned to the soil by plouging in or burning trash. However, full research into fertiliser requirements is essential.

(f) Harvesting

The wider row spacing will permit the passage of tractor and trailer between the rows during harvesting. The wider spacing could be used between alternative rows thus allowing two rows to be harvested per harvesting 'run'. No fundamental changes are considered necessary to the packing methods. Care should be taken however, to prevent too much bruising, too much fruit stalk, too little crown and inefficient cutting when stems are taken off.

(g) Yields

Expected yields under improved management are difficult to assess. La Rosa Filippo (1966) considered 360 quintals/ha/year to be possible of which 300 quintals/ha/year would be exportable quality. The SIATSA agronomists considered a net exportable yield of 250 to 280 quintals/ha/year and reported that good farms on the Juba river were probably currently producing 250 quintals/ha/year, although accurate figures were not available. A single fertiliser trial carried out by CARS on a farm near Afgoi produced 380 to 540 quintals/ha/year (CARS, 1968). Present gross yields average 200 quintals/ha/year of which about 130 quintals/ha/year are exportable. It is likely, therefore, that yields of 250 quintals/ha/year could be obtained under good management with sound nematode control. These levels could be expected from first planting since by the time Bardheere dam is constructed the appropriate field management should be available and effects of soil disturbance will no longer be applicable. In addition, 50 quintals/ha/year will be available for sale on the local market.

2.3 Cropping Patterns

The major factors influencing the combinations of crops in the cropping patterns are the soils, the crop calendars, the relative profitability of the crops and their demand for labour throughout the year.

2.3.1 Soils

Although a fairly wide range of crops can be grown on the clay soils, they are particularly well suited to the cultivation of rice in a basin or paddy irrigation system. The coarser textured levee soils which for topographic reasons will have to be irrigated by overhead sprinklers, will allow a wider range of crops to be grown. To utilise the soils effectively, therefore, at least two cropping patterns, one for the clays based on rice and one for the levees, should be prepared.

2.3.2 Crop Calendars

Figure 2.1 shows the planting, growing and harvesting periods for each crop. Cotton is a der season only crop whilst rice is treated as a gu season crop. Rice could be grown in the der season but it is thought that the problem with bird damage could be greater and the irrigation requirements would be higher. Therefore of the four main crops, only maize is regarded as a potential crop for both the gu and der seasons. Figure 2.1 also shows the average monthly rainfall distribution throughout the year and a diagrammatic representation of river flows, and demonstrates the need for varieties with short growing seasons (105 to 110 days) if double-cropping is to be achieved easily. Lastly, it shows clearly that cotton will not permit a second crop to be grown with it and will have to be preceded by a fallow period in the gu season.

2.3.3 Relative Profitability

The capital costs of the irrigation works and association infrastructure at Mogambo will be high. If the scheme is to be economically justifiable, every effort will have to be made to increase output through intensification of the cropping pattern and through the inclusion of crops which give the highest returns. The net margin (i.e. the gross revenues less attributable farm costs) is the best means of comparing the relative economic attractiveness of crops and is shown for all crops in Table 2.2 below. Basin rice clearly gives the greatest potential returns of the annual crops and warrants inclusion to the maximum extent possible. Upland rice gives the next highest returns and is followed by cotton, maize and sesame. The returns from sesame are so low that its inclusion in the cropping patterns cannot be justified.

The financial attraction of cotton is reduced since the cropping intensity is limited to 100%. Bananas show high net margins but a paddy rice-maize 200% cropping pattern would achieve the same levels of returns.

TABLE 2.2

Net Margins for Potential Crops at Economic Prices (SoSh/ha)

Crop	Gross revenue	Attributable costs(1)	Net margin
Rice (paddy)	9 688	3 279	6 409
Rice (upland)	8 477	3 220	5 257
Cotton (hand picked)	7 900	3 350	4 550
Cotton (machine picked)	6 320	3 567	2 753
Sesame	2 680	1 869	811
Maize (sprinkler irrigated)	4 800	2 365	2 435
Maize (basin irrigated)	4 800	2 432	2 368
Bananas (average over 6 years)	18 167	8 536	9 631

Note: (1) Includes materials, machinery operating costs, unskilled labour and drying, storage and milling costs where necessary.

Source: Annex 7

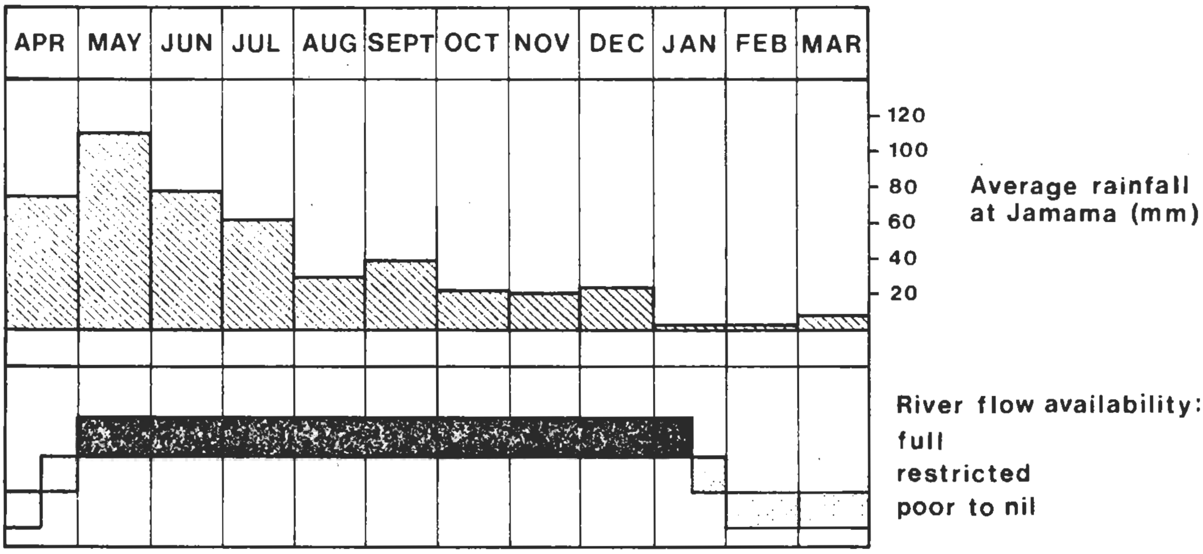
2.3.4 Clay Soils: Cropping Pattern

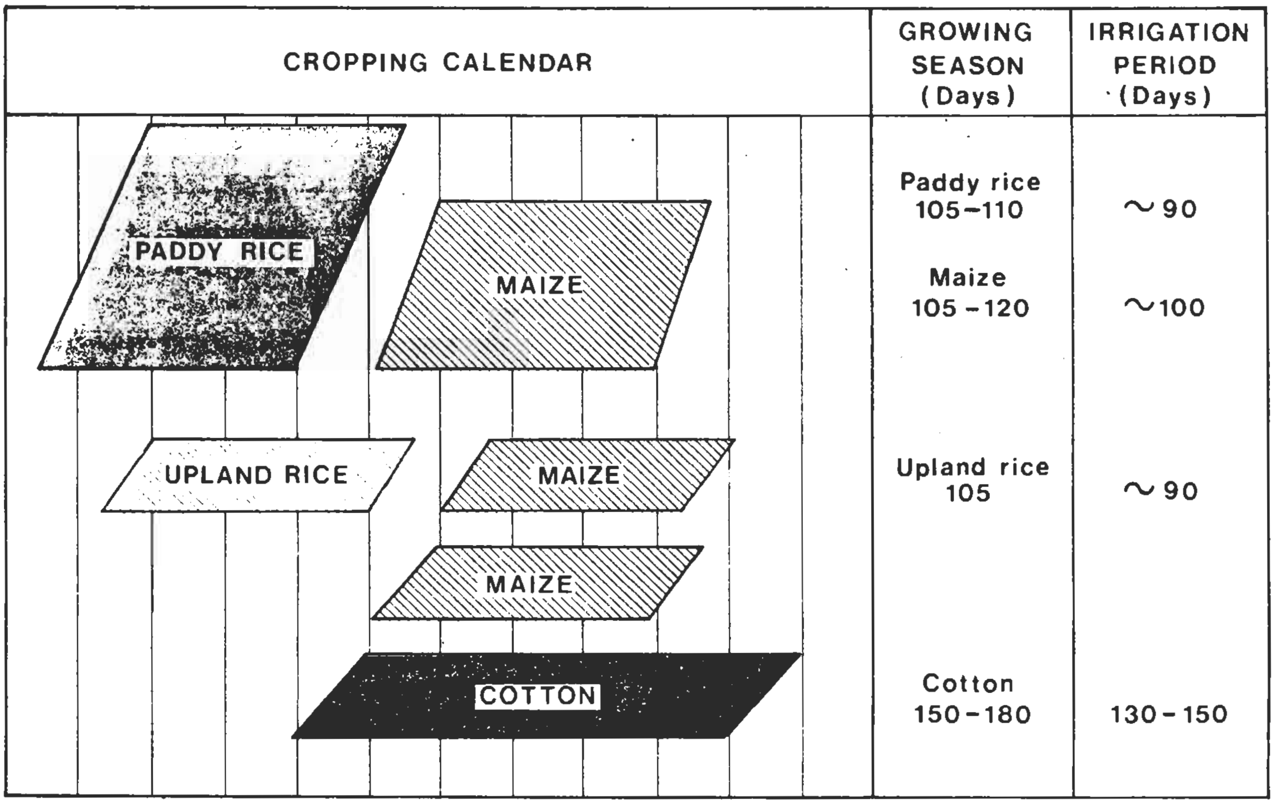
The predominantly clay soils comprise the basin clays and the depression sub-unit of the meander complex (or levee soils) which together account for approximately 52% of the total cultivable area. These soils, because of their fine texture, are particularly well suited to the cultivation of rice in a basin irrigation system. Since rice gives the highest returns of the major annual crops it should be included to the maximum extent possible and consequently it is recommended for cultivation throughout the entire area of clay soils during the gu season. Sesame and maize, the potential crops for double-cropping with rice, are generally better adapted to the der season. Of the two crops, maize is preferred. Sesame, besides its low return, is particularly susceptible to waterlogging and would be more difficult to cultivate on the clay soils. A cropping pattern of 100% rice in the gu season followed by 70% maize in the der is therefore proposed. Double cropping of rice has been considered but this would require a higher degree of management expertise and there is a danger of a build-up of soil toxicity and aquatic weeds. This combination has not therefore been included but trials could be carried out in the early years of the project to test the viability of double cropped rice.

2.3.5 The Levee Soils: Cropping Pattern

The coarser textured soils of the meander complex amount to about 3 100 ha or 48% of the total area. The pattern proposed comprises a mixture of maize, cotton (mainly hand picked) and upland rice as follows:-

Rainfall, riverflow and crop calendar relationships





	Gu season		Der season	
	ha	%	ha	%
Maize	-	-	2 000	65
Upland rice	1 000	32	-	-
Cotton	-	-	1 100	35

Overall it has an intensity of 132% with 100% of the area cropped in the der season and 32% cropped in the gu. The area of cotton is limited to 1 100 ha because of its high labour demand at picking and the distinct possibility that labour would not be available to pick larger areas.

2.3.6 The Project Cropping Pattern

The composite cropping pattern for the clay and levee soils at full maturity is shown in Figure 2.2. The overall intensity amounts to 152% with 68% intensity in the gu season and 84% intensity in the der.

2.3.7 Post Bardheere Dam Cropping Patterns

The main impact of the construction of Bardheere dam will be to enable bananas to be included in the cropping pattern for the levee soils and to allow a longer season and higher yielding rice varieties to be cultivated because of earlier planting in April. It is likely, however, that no more than 1 200 ha of bananas would be grown. This would be a significant increase on the total area already under bananas nationally and would only require a small.increase in the design capacity of the irrigation works for annual crops. The system would need some overdesign for the early stages of the scheme so that the increased capacity would be available after Bardheere dam is constructed. This is discussed in more detail in Chapter 5. The bananas would replace the der season maize (1 000 ha) and some of the upland rice-maize rotation if required.

2.4 Agricultural Organisation and Implementation

2.4.1 Agricultural Organisation

The management and organisation of agricultural production within the project is discussed in detail in Annex 6. It is proposed that the cultivable area be divided into four farms, each of which would have an associated village to house the labour force and their families. Each farm would comprise a proportion of clay and levee soils and their net cultivable areas would be as follows.

Farm	Area (ha)
A	1 821
B	1 720
C	1 404
D	1 485
Total	6 430

The farms would have their own complement of agricultural machinery and facilities would be available for daily maintenance of equipment. Repairs and routine servicing, however, would be carried out at a central workshop (Section 3.4.1) at project headquarters. Crop handling, storage and processing facilities would also be centralised at the project headquarters. Each farm would, therefore, have its own office, machinery parking area, limited workshop, oil, grease and fuel store, and limited storage space for agri-chemicals, seeds and fertilisers. The bulk of the fertilisers would be stacked outside.

2.4.2 Implementation

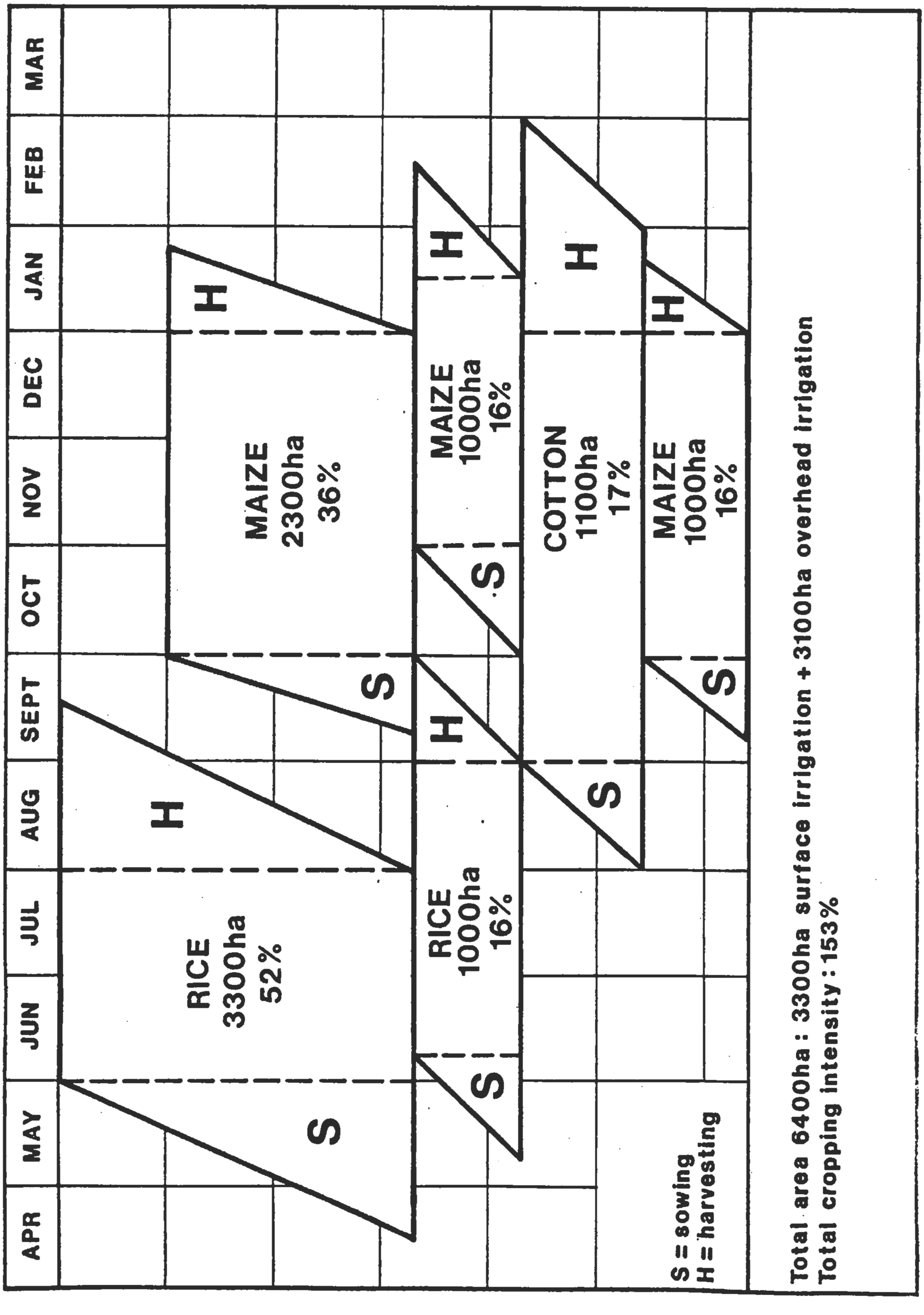
The project would be developed over a five year period with the first areas of crops being cultivated in the second year. Thoughout this period the area under production would be built up and cropping intensity gradually increased. The planned rate of agricultural implementation is indicated in Table 2.3.

TABLE 2.3

Build-up in Net Cropped Areas by Year of Development (ha)

	Year 2		Year 3		Year 4		Year 5	
	Gu	Der	Gu	Der	Gu	Der	Gu	Der
Clay Basin Soils								
Paddy rice	243	-	1 107	-	2 538	-	3 321	-
Maize	-	648	-	1 620	-	1 620	-	2 295
Fallow	-	-	-	-	-	918	-	1 026
Levee Soils								
Upland rice	-	-	-	-	724	-	998	-
Cotton	-	-	-	449	-	938	-	1 103
Maize	-	-	-	-	-	1 173	-	2 006
Fallow	-	-	-	-	449	-	2 111	-
Total cropped area	243	648	1 107	2 069	3 262	3 731	4 319	5 404
Total fallow area	-	-	-	-	449	918	2 111	1 026

Note: Changeover to bananas in Year 7 is shown in Chapter 13 (Table 13. 2)


APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
S
H
RICE
3300ha
52%
MAIZE
2300ha
36%
RICE
1000ha
16%
MAIZE
1000ha
16%
COTTON
1100ha
17%
MAIZE
1000ha
16%
S = sowing
H = harvesting
Total area 6400ha : 3300ha surface irrigation + 3100ha overhead irrigation
Total cropping intensity : 153%

2.5 Review of the TAMS/FINTECS Proposals

The TAMS/FINTECS study proposed the following cropping pattern at full development :-

Crop	Gu season (hectares)	Der season (hectares)
Maize	2 405	-
Sesame	-	1 450
Rice	-	955
Clover	955	955
Legumes	2 900	1 450
Cotton	-	1 450

In this supplementary study it is agreed that these crops with the exception of clover, could be grown successfully at Mogambo, and that conditions would be unsuitable for groundnuts and sunflowers as claimed. Perennial crops, apart from clover, were not proposed in the TAMS/FINTECS study, presumably due to the uncertainty of water supply.

Crop yields assumed were of the same order of magnitude as in this study, with the exception of maize for which 5.0 tonnes/ha was claimed, which is considered to be too high.

The selection of the appropriate ratios of these potential crops into a final cropping pattern seems to have been somewhat arbitrary. Also, the cost/price relationships for the feedlot project changed considerably during the period between the TAMS/FINTECS report and this study (see Annex 4). Because the feedlot is now uneconomic fodder crops are inappropriate, and it should be noted that there is no technical evidence that berseem clover can be grown successfully in southern Somalia.

In addition, the net margins implied in the TAMS/FINTECS data do not seem to have been reflected in the crop rankings. Based on Tables V-19 and IX-15, net margins for each crop can be derived as follows :-

	SoSh/ha
Rice	7 900
Cotton	4 500
Legumes	3 700
Maize	2 600
Sesame	1 900

These net margins do not include direct labour costs, the inclusion of which would reduce the margins of the hard harvested crops, cotton and maize. From these net margins a much higher proportion of rice would have been expected in the final rotation, with some additional cotton.

The returns for sesame would not seem to justify such a large area, and cannot be harvested using the rice machinery until non-shattering varieties are developed.

Legumes show a reasonably high net margin, based on an assumed price of SoSh 2 500 per tonne. However, since the 1978 Ministry of Agriculture estimates show a total national production of 10 000 tonnes of beans, of which none were grown in the south, it must be assumed that the proposed additional output of 7 830 tonnes would tend to depress the local price, and heavy transport costs would be incurred in shipping to other areas (legumes are not marketed by ADC). Thus, the claimed returns from legumes are probably too high.

To summarise, the choice of crops proposed by TAMS/FINTECS is reasonable but the proportions of each are questionable, and there is doubt about the advisability of recommending berseem clover on such a scale.

CHAPTER 3

FARM LABOUR AND MACHINERY UTILISATION

3.1 The Farming System

The major factor influencing the farming system and hence the dependence upon either labour or machinery, is the form of development (whether smallholder settlement or state owned farm) which is proposed for the project. The Government policy for Mogambo is to develop the area as a large scale farm which would be operated by a management structure appointed by the state.

Although a large scale farm will inevitably be more dependent upon the use of machines than would a smallholder's settlement scheme where there would be an abundant supply of family labour available, the extent to which the farming operations are mechanised remains an important issue. Theoretically, so long as there is an adequate supply of labour available, virtually all the operations on a large scale farm could be carried out manually. In practice, however, large labour forces create logistical (housing and transport) and organisational difficulties and frequently the necessary control over the timeliness of completion and the quality of work is impossible to achieve. It is necessary therefore to find a balance between the use of machines and labour.

In the preceding chapter recommendations have been made regarding the mechanisation of certain operations such as land preparation, planting and application of fertiliser. The decision to mechanise these operations virtually completely has been made for the following reasons: the high intensity of the cropping programme curtails the time available to carry out operations, the heavy textured soils will require considerable inputs of power during limited periods (because of soil moisture conditions) to create a reasonable seed bed and lastly, mechanical planting is proposed because it is the best means of achieving the correct plant spacing and population over large areas. Fertiliser application has been mechanised mainly because it is linked to the proposed method of planting (combine drill) and because it is also tied to the land preparation operations (spinner broadcasting prior to final discing). Where nitrogen applications are split between a basal component and a top-dressing, the choice remains to top-dress by hand or by machine. In the case of rice the only alternative to hand top-dressing is aerial application. With cotton and maize, side-dressing, using fertiliser attachments on cultivation equipment, is an economical means of applying fertiliser and is recommended.

Herbicide applications are recommended as the main means of maintaining weed control and consideration was given to the alternatives of applying them by knapsack sprayer, tractor and aerial means. Again, timeliness is an important factor and given that on average there are likely to be no more than three hours per day when wind velocities will permit spraying, mechanical application of blanket sprays had to be adopted. Aerial application at a cost of around SoSh 35/ha is less expensive than tractor spraying and allows much greater flexibility in timing in that it is not dependent upon ground conditions. With rice, of course, there is no alternative to aerial spraying. The general policy adopted therefore has been to apply blanket sprays by air and to supplement these with spot applications by battery operated ULV sprayers where necessary.

Some mechanical weed control using rolling tine cultivators is also recommended for the maize and cotton crops. Rolling tine cultivators are a well tried and effective means of achieving weed control in these crops. Some 'spot' hand weeding is also likely to be necessary and allowance is made for this in the labour budgets.

The recommendations for the method of application of pesticides rests on similar arguments to herbicides; timeliness is essential and the period when spraying can be carried out is limited. There is therefore little alternative to aerial application supported by spot spraying using knapsack sprayers. Of the crops to be grown cotton will be the most dependent upon pest control sprays.

Machine and hand harvesting methods are recommended, depending upon the crop. Rice and maize will be machine harvested using a combine harvester. The same machine can be adapted to handle both crops by changing the header units and threshing mechanism. Hand harvesting of maize is a possibility but since the der maize harvest coincides with cotton picking and would therefore amplify an already marked peak in labour demand, mechanised maize harvesting is recommended.

Cotton harvesting will be a hand operation and will require hiring of fairly large numbers of casual labour. There are possibilities of eventually introducing a mechanised harvesting system for cotton and, in order to investigate this possibility further, a trial area of 100 ha of narrow-row cotton has been included. This will be harvested by a stripper harvester. Irrigation and furrow and bund maintenance will all be manual operations as well major part of the crop handling and processing work.

Bananas, which can be introduced into the cropping pattern after construction of Bardheere dam, are the most labour intensive of all of the crops since planting, weed control, pesticide application, harvesting and packing are virtually all hand operations.

3.2 Farm Labour Requirements

3.2.1 Without Bardheere Dam

On the basis of the recommendations regarding mechanisation of farm operations discussed in the preceding section, the labour requirements have been estimated for each crop and are summarised in Table 3.1. Table 3.2 shows the distribution of this requirement throughout the crop growing season. Cotton is clearly the most labour demanding with a requirement of almost five times that of maize or rice. The major contributor to this high demand is the need for cotton pickers at harvest which is spread over a three month period.

These requirements have then been combined with the cropping pattern and crop areas at maturity to indicate the size of labour force (Table 3.3) necessary to carry out all field operations. The table indicates that a permanent force of some 900 labourers would be required and that this would have to be supplemented by casual labour in the peak demand months of October, December, January and February. In addition to these there will be a requirement for about 50 foremen. The build-up in the labour force between years 2 and 5 of the project development programme is shown in Table 3.4. The permanent force would rise from 60 members in year 2 to 300 in year 3 and 700 in year 4. The numbers of foremen would increase from 12 in year 2 to 30 in year 3 and 50 in year 4.

TABLE 3.1

Crop Labour Requirements by Operation
(man-days/ha)

Operation	Paddy rice(1)	Maize(1)	Maize(2)	Cotton(2)	Upland rice(2)
Bund and furrow maintenance	4.0	4.0	1.0	1.0	1.0
Spraying (aerial)(3)	0.2	0.1	0.1	1.0	0.3
Spot spraying	0.2	0.2	0.2	0.2	0.7
Spot weeding	-	5.0	5.0	5.0	10.0
Irrigating	12.0	9.0	6.0	10.0	5.0
Top-dressing	1.0	-	-	-	1.0
Harvesting(4)	1.0	1.0	1.0	75.0	1.0
Processing(4)	1.0	-	-	-	1.0
Miscellaneous	3.0	2.5	2.5	6.0	3.0
Total	22.0	22.0	16.0	98.0	23.0

Notes:
(1) Basin irrigated
(2) Sprinkler irrigation
(3) Includes labour used for marking and for mixing and loading of chemicals at the aircraft
(4) Includes loading and handling.

TABLE 3.2

Crop Labour Requirements by Month
(man-days/ha)

Crop	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Paddy rice	2	5	5	5	4	1	-	-	-	-	-	-
Upland rice	1	5	6	6	4	1	-	-	-	-	-	-
Der maize (basin)	-	-	-	-	-	4	6	6	3	3	-	-
Der maize (sprinkler)	-	-	-	-	-	3	5	4	3	1	-	-
Cotton (sprinkler)	-	-	-	-	3	5	6	4	15	35	23	7

Table 3.5 shows the calculation of the labour additional to the 'core' force that will be needed in each month. The requirement, in man years, rises from 24 in year 2 to 196 from year 6 onwards.

TABLE 3.3

Annual Requirement for Unskilled Labourers at Project Maturity

(persons/month)

Crop	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Paddy rice (3 321 ha)	276	691	691	691	553	138	-	-	-	-	-	-
Upland rice (998 ha)	42	208	249	249	166	42	-	-	-	-	-	-
Maize - basin (2 295 ha)	-	-	-	-	-	383	574	574	287	287	-	-
Maize - sprinkler (2 006 ha)	-	-	-	-	-	251	418	334	251	84	-	-
Cotton (1 103 ha)	-	-	-	-	138	230	276	184	688	1 608	1 057	321
TOTAL	318	899	940	940	857	1 044	1 268	1 092	1 226	1 979	1 057	321

TABLE 3.4

Summary of Monthly Demand for Agricultural Labourers during Project Years 2, 3 and 4

Project year	Month												Remarks
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
2	20	51	51	51	40	119	162	162	81	81	-	-	Build up the permanent labour force from 50 to 130 by the end of the year employing casual labour where necessary Average taken as 60
3	92	230	230	230	240	410	517	480	483	858	430	131	Build up from 130 to 500 during the year employing casual labour as necessary Average taken as 300
4	241	679	709	709	660	748	884	757	935	1 619	899	273	Build up permanent labour from 500 to 900 during the year Average taken as 700

TABLE 3.5

Calculation of Annual Labour Requirements for Agricultural Labour in Excess of Basic Labour Force

Level of basic labour force	Year 2 60		Year 3 300		Year 4 700		Year 5 900		Year 6 onwards 900	
	Men per month	Excess required	Men per month	Excess required	Men per month	Excess required	Men per month	Excess required	Men per month	Excess required
January	0	-	81	-	858	158	1 619	719	1 979	1 079
February	0	-	0	-	430	-	899	-	1 057	157
March	0	-	0	-	131	-	273	-	321	-
April	20	-	92	-	241	-	318	-	318	-
May	51	-	230	-	679	-	899	-	899	-
June	51	-	230	-	709	9	940	40	940	40
July	51	-	230	-	709	9	940	40	940	40
August	40	-	240	-	660	-	857	-	857	-
September	119	59	410	110	748	48	1 044	144	1 044	144
October	162	102	517	217	884	184	1 268	368	1 268	368
November	162	102	480	180	757	57	1 092	192	1 092	192
December	81	21	403	183	935	235	1 226	326	1 226	326
Total extra man months required		284		690		700		1 829		2 346
Total extra man years		24		58		58		152		196

3.2.2 With Bardheere Dam

The introduction of 1 000 ha of bananas instead of maize would require the labour force to be at least doubled. The annual labour requirement for bananas is summarised in Table 3.6 which indicates a maximum requirement of 422 man-days/ha in the five years following planting but an average requirement over the plant life of six years of 385 man-days. It is estimated that a permanent force of some 1 500 labourers could adequately handle the crop.

TABLE 3.6

Bananas: Labour Requirements by Operation
(man-days/ha)

Operation	Plant crops	Years 2 to 6(1)
Planting and replanting(2)	62	-
Herbicide application	1	-
Spot weeding	10	36
Fertiliser application	15	20
Nematocide application	10	10
Pruning	40	60
Trash removal/splitting	28	63
Irrigation	20	20
Harvesting and loading	-	175
Miscellaneous	19	38
TOTAL	205	422

Notes: (1) Excludes labour for packing which is organised by the ENB
(2) Includes the initial application of fertiliser and nematocide

3.3 Machinery Utilisation

3.3.1 Machinery Requirements

It has been argued in Section 3.1 that a fairly high level of mechanisation will be necessary if the field operations are to be achieved within the limited time available and if the intensive cropping programme proposed is to be completed successfully each year. Also, the uncertainty regarding the overall availability of labour combined with demands for labour from neighbouring projects (Juba Sugar project and Trans-Juba livestock) have made reliance upon a mechanised farming system necessary. In determing an appropriate system, large robust equipment with a high output has been preferred. Every effort has been made to reduce the range of equipment to the minimum and to avoid highly sophisticated and specialised machinery. Thus the main power units have been reduced to three types of tractor (one tracked and two wheeled). Land preparation operations have been standardised for most crops and reduced to three operations (ripping or soil saving, discing and levelling) and harvesters which can be conveniently modified to handle more than one crop (maize and rice) are proposed. Aerial application of pesticides and herbicides is recommended wherever possible as even using contractors the cost of aerial application (approximately SoSh 35/ha) is relatively low. It is the most effective means of application and is not affected by ground conditions after rainfall or irrigation. The use of contractors would greatly simplify the operation and is strongly recommended. Consideration has been given to the restrictions to the timing of aerial spraying caused by wind. It has been assumed that spraying could be accomplished for a maximum of three hours per day.

The various mechanised operations necessary for each crop are summarised in Table 3.7 and the outputs of the specified machinery are given in Table 3.8. Tables 3.7 and 3.8 together with the proposed cropping programme have been used to determine the time available for each operation and the number of implements and machines necessary to complete the operations on time. The aim has been made to meet the peak demand and to achieve a reasonable level of machinery utilisation throughout the year.

TABLE 3.7

Mechanised Field Operations by Crop(1)

Field operation	Basin soils		Levee soils		
	Gu paddy rice	Der maize	Gu upland rice	Der cotton	Der maize
Chisel ripper	*		*	*	
Soil saver		*			*
Heavy disc harrowing	*		*	*	
Land planing(2)	*				
Fertiliser application	*	*	*	*	*
Light harrowing	*	*	*	*	*
Planting/drilling	*	*	*	*	*
Inter-row cultivation		*		*	*
Ridging(3)	*	*			
Combine harvesting	*	*	*		*
Crop transport	*	*	*	*	*
Flail (post harvest)	*	*	*	*	*

Notes : (1) Does not include aerial spraying
(2) All fields are land planed after land levelling (basin soils) or after bush clearance and removal of termitaria (levee soils)
(3) To establish temporary bunds for water distribution

TABLE 3.8

Field Machinery: Specification and Estimated Output

Implement or machine	Class of tractor	Implement effective working width (m)	Working speed (km/h)	Theoretical output (ha/h)	Efficiency factor (%)	Field output (ha/h)	Field output (h/ha)	Working(1) time (h/d)	Output/ day (ha)
Chisel ripper	Crawler 150 hp	4.0	4.0	1.6	80	1.3	0.77	12	15.6
Soil saver	Crawler 150 hp	3.0	4.0	1.2	75	0.9	1.11	12	8.4
Disc harrow	Crawler 150 hp	4.5	5.0(2)	2.3	80	1.8	0.56	12	21.6
Land plane	4 WD(3) 110 hp	3.7	6.0	2.2	80	1.8	0.56	10	18.0
Fertiliser broadcaster	4 WD 110 hp	10.0	6.0	6.0	70	4.2	0.24	10	42.0
Combine drill	4 WD 110 hp	5.0	6.0	3.0	70	2.1	0.48	10	25.2
Inter-row cultivator	75 hp	3.5	5.0	1.75	70	1.2	0.83	10	12.0
Border disc (temporary bunds)	75 hp	-	5.0	-	80	0.4 km bund/h	-	-	-
Combine harvester (rice)	SP(4) 104 hp	3.6	4.0	1.5	70	1.1	0.91	10	11.0
Combine harvester (maize)	SP 104 hp	2.8	4.0	1.2	70	0.8	1.25	10	8.0
Crop transport(5)	110 hp and 75 hp tractors and 5 and 10 tonne trailers								
Flail	4 WD 110 hp	3.0	6.0	1.8	80	1.5	0.69	10	15.0

Notes:
(1) Two drivers per machine working in 7 hour shifts; one hour break allowed for servicing.
(2) Rate for first discing, the second would be at a faster rate.
(3) 4 WD = 4 wheel drive
(4) SP = self propelled
(5) Transport of grain from the field would be in 10 tonne trailer and 110 hp tractor combinations; other transport would be mainly by 75 hp tractor and 5 tonne trailers.

TABLE 3.9

Estimated Numbers of Tractors and Machinery Required at Full Development

Implement or machine	Class of tractor	Field output (h/ha)	Total area per year (ha)	Time worked (h)	Time available in season (d)	Working(1) day (net hours)	Theoretical implement requirement (numbers)	Actual(2) implement requirement (numbers)
Chisel ripper	Crawler 150 hp	0.77	5 422	4 175	90	12	4	5
Soil saver	Crawler 150 hp	1.11	4 301	4 774	65	12	6	8
Disc harrow	Crawler 150 hp	0.56	15 145	8 481	120	12	6	8
Land plane	4 WD 110 hp	0.56	3 321	1 860	50	10	4	5
Fertiliser broadcaster	4 WD 110 hp	0.24	9 723	2 333	80	10	3	4
Combine drill	4 WD 110 hp	0.48	9 723	4 667	70	10	7	9
Inter-row cultivator(3)	75 hp	0.83	5 404	4 485	80	10	6	7
Border disc	74 hp	0.4 km bund	-	1 000	40	10	3	4
Flail	4 WD 110 hp	0.69	9 723	6 709	100	10	7	9
Transport - 10 t trailer	4 WD 110 hp	1.0	9 723	9 723	-	-	-	14
- 5 t trailer	75 hp	0.5		4 862	-	-	-	8
Combine harvester (rice)		0.91	4 319	3 930	25	10	16	18 basic units (14 maize headers and 18 rice headers)
Combine harvester (maize)		1.25	4 301	5 376	45	10	12	
Cotton stripper		-	-	-	-	-	-	1
Number of tractors:								
Crawler tractors 150 hp total hours worked				17 430	1 500	-	12	14
4 WD 110 hp total hours worked				25 291	1 200	-	22	24
75 hp total hours worked				10 347	1 200	-	8	9

Notes: (1) Assumes 2 daily shifts of 7 hours for each tractor; one hour break allowed for servicing.
(2) Allows for peak periods and 10% additional machines in case of delays in repair.
(3) Inter-row cultivation also includes side placement of fertiliser.

TABLE 3.10

Machinery Requirements to Project Maturity (numbers)

	Year 2	3	4	5
	Number of Machines			
Tractors :				
Crawler tractors	2	6	11	14
4 WD tractors	3	10	19	24
2 WD tractors	2	3	7	9
Implements :				
Chisel ripper	1	2	4	5
Soil saver	2	4	6	8
Disc harrow	2	4	6	8
Land plane	1	2	4	5
Fertiliser broadcaster	1	2	3	4
Combine drill	2	4	7	9
Inter-row cultivator	1	3	5	7
Border disc	1	2	3	4
Flail	2	4	7	9
Trailer 10 tonne	2	8	12	14
Trailer 5 tonne	2	4	6	8
Harvesters :				
Combine harvester units	2	6	12	18
Maize headers	2	5	10	14
Rice headers and threshing modifications	2	6	12	18
Cotton stripper	-	-	1	1

TABLE 3.11

Machinery Operating Hours per Hectare of Crop

Operation	Basin soils		Levee soils		
	Gu paddy rice	Der maize	Der cotton	Der maize	Gu upland rice
Chisel ripping	0.77	-	0.77	-	0.77
Soil saving	-	1.11	-	1.11	-
Heavy disc harrowing	0.56	0.56	0.56	0.56	0.56
Land planing	0.56	-	-	-	-
Fertiliser application	0.24	0.24	0.24	0.24	0.24
Light harrowing	0.56	0.56	0.56	0.56	0.56
Planting	0.48	0.48	0.48	0.48	0.48
Inter-row cultivation (75 hp)	-	0.83	0.83	0.83	-
Ridging (75 hp)	0.25	0.25	-	-	-
Crop transport	1.5(1)	1.5(1)	2.0(2)	1.5(1)	1.5(1)
Flail	0.69	0.69	0.69	0.69	0.69
Combine harvesting	0.91	1.25	-	1.25	0.91
Crawler tractor hours	1.89	2.23	1.89	2.23	1.89
4 WD tractor hours	2.97	2.41	2.41	2.41	2.41
75 hp tractor hours	6.75	1.58	1.83	1.33	0.50
TOTAL tractor hours(3)	5.61	6.22	6.13	5.97	4.80

Notes: (1) 1 hour 4 WD tractor and 10 tonne trailer and 0.5 hour 75 hp tractor and 5 tonne trailer.

(2) 1 hour 4 WD tractor and 10 tonne trailer and 1 hour 75 hp tractor and 5 tonne trailer.

(3) Excludes combine harvesting time.

The complement of machinery necessary at full development is given in Table 3.9, whilst the requirement during the pre-maturity period, years 2 to 5, is given in Table 3.10. By year 5, 47 tractors (14 tracked and 33 wheeled) would be required. In all, 18 basic combine harvesters would be necessary and these would be equipped with 14 maize header units and 18 rice headers and concaves and drums. At least 6 of the combines would be equipped with half tracks for harvesting rice when conditions are abnormally wet.

3.3.2 Machinery Requirements by Crop

The estimated tractor and machinery operating hours per hectare of each crop are given in Table 3.11 which provides the basis for estimating machinery operating costs (Annex 7). Because field operations have been standardised as far as possible, the variation between the numbers of operating hours per crop is small.

3.3.3 Machinery Replacement

The machinery replacement policy has been based on the expected working life of the machine in terms of total hours of usage compared with the numbers of hours worked per year. The basic assumptions are given in Table 3.12.

TABLE 3.12

Expected Life of Agricultural Machinery

Machine	Approximate hours worked per annum	Expected life (hours)	Expected life (years)
Tractors:			
Crawler tractor	1 500	10 500	7
Wheeled tractor	1 200	7 200	6
Implements			
Chisel ripper	800	6 000	7
Soil saver (plough)	800	6 000	7
Disc harrow	1 000	6 000	6
Land plane	500	4 000	8
Fertiliser broadcaster	800	3 000	5
Combine drill	600	4 000	6
Inter-row cultivator	800	5 000	6
Border-disc	400	4 000	10
Flail	800	5 000	6
Combine harvester	600	2 500	4

3.3.4 Drivers and Machinery Operators

Table 3.13 summarises the requirement for skilled tractor drivers and machinery operators. The estimate is based on the assumption that tractors and machinery will generally be used for two shifts each of seven hours per day. Provision has been made for training replacement drivers by increasing the basic requirement by 25%.

TABLE 3.13

Requirement for Drivers and Machinery Operators

	Year			
	2	3	4	5
Number of drivers/operators	23	63	125	165

3.4 Machinery Support Services

The two main components of the supporting services for machinery will be the servicing and repair facilities and training for drivers, operators and workshop staff.

3.4.1 Servicing and Repair Facilities

The servicing and repair facilities would comprise a comprehensive workshop and mechanical store at the project headquarters and two mobile repair units. Each farm would have adequate facilities for daily maintenance and tyre repairs. The main workshop would be provided with facilities for the following:-

(a) fuel storage for diesel and petrol

(b) mechanical repairs

(c) body and paintwork repairs (including welding)

(d) electrical repairs

(e) a machine shop for making some spare parts where necessary.

The workshop would also house facilities for general maintenance on the project and would have plumbing and joinery shops.

The two mobile workshops would each comprise a long wheel base, 4 wheel drive pick up vehicle equipped with an air compressor, generator, welding plant and small crane. It would also have storage space for oil, water, grease, spare parts and a range of small tools.

Additional plant and equipment and facilities would comprise a low loader trailer with winch, a fork lift truck, two water and fuel tankers (5 000 litres capacity), a tractor and trailer for general use and a high pressure hosing down bay.

3.4.2 Training

From the inception of the project, considerable emphasis will have to be given to training and equipping staff for the demanding and complex task of managing the project and keeping plant and machinery operating effectively. A training manager responsible for co-ordinating all aspects of training has therefore been proposed as part of the overall organisation and management structure (Annex 6). In addition to organising appropriate formal training courses with institutions and manufacturers the training manager would also be responsible for monitoring the progress of trainees throughout the training period.

Specific training for workshop staff would be carried out mainly on-site by ensuring that trainees were attached as assistants to skilled and experienced workshop staff. This policy would exist at all levels from workshop supervisor to mechanic, and would be the backbone of the training programme. It would be supplemented by formal courses covering specific aspects. These could well be arranged through agricultural engineering institutions and through the manufacturers of agricultural machinery. Every effort should be made to persuade manufacturers to provide personnel to run training courses for mechanics and drivers and, wherever possible, these should be linked with purchase of machinery.

Training of drivers and operators will be as important as training workshop staff and again it is recommended that the approach described above supplemented by some formal instruction is adopted. A total of 25% additional trainee drivers have been allowed for. These would be attached to the more experienced drivers and would remain trainees until they were competent operators and a vacancy in the permanent force of drivers arose.

3.5 Crop Spraying

Aerial application of herbicides and pesticides has been recommended on the grounds of its relatively low cost, the effectiveness of cover achieved and because of its independence from ground conditions at the time of application. It is preferred to the use of tractor mounted sprayers for application of blanket sprays. There will however be a requirement for 'spot spraying' of isolated areas of weeds or outbreaks of pests which would not justify the mobilisation of an aircraft. The use of motorised knapsack sprayers to cover these areas is recommended and has been budgeted for in the estimation of labour requirements. It is estimated that at full development of the project, up to 20% of the total crop hectarage or around 2 000 ha may require spot spraying each year. Using motorised sprayers this area could be covered in around 3 000 spraying hours at a rate of 1.5 h/ha. Assuming that the period available for spraying is 50 days and that suitable weather conditions (no rain and wind speeds below 4 m/s) prevail for 50% of the time, then a gang of 20 men could theoretically cope with the spot spraying requirements. To allow for repairs and unexpected peaks in demand, the purchase of 40 knapsack sprayers (10 per farm) has been provided for in the estimates of equipment purchases.

The supporting facilities necessary for aerial spraying would include:-

(a) construction of an air strip of 800 m minimum length and overall cleared width not less than 60 m

(b) two mixing tanks and water pumps to transfer the chemical to the aeroplane

(c) aviation fuel tanks

(d) accommodation for the pilots of the aircraft.

Table 3.14 gives the number of aerial sprays per crop for weed and insect control, fertiliser application and desiccation prior to mechanical harvesting of cotton.

TABLE 3.14

Aerial Sprays per Hectare of Crop

	Herbicide	Insecticide	Fertiliser	Desiccant
Paddy rice	1	2	1	-
Upland rice	2	2	1	-
Maize	1	2	-	-
Cotton - hand picked	1	9	-	-
Cotton - machine picked	1	9	-	1

CHAPTER 4

CROP PROCESSING, STORAGE AND AGRICULTURAL BUILDINGS

4.1 Crop Production

At full development of the project, the annual net cropped area will be 9 723 ha, comprising 4 319 in the gu season and 5 404 in the der. The estimated production will amount to about 36 700 tonnes annually with 16 800 tonnes in the gu and 19 900 tonnes in the der. The distribution of this production between the gu and der seasons is shown in Table 4.1. The rice crop will have the major storage requirement as it is expected that the hulling process will not be completed until about nine months after harvest. Maize will be dried and stored for a minimal period prior to despatch to the ADC. Storage for cotton will also be minimal since it is planned to bulk the cotton in heaps in the field and despatch from there to the ginnery.

TABLE 4.1

Net Cropped Areas and Crop Production at Project Maturity

Crops	Net area (ha)	Projected yield (ha)	Total production (t)
Gu Season			
Paddy rice	3 321	4.0	13 284
Upland rice	998	3.5	3 493
Sub-total	4 319		16 777
Der Season			
Maize	4 301	4.0	17 204
Cotton - hand picked	1 003	2.5	2 508
Cotton - machine picked	100	2.0(1)	200
Sub-total	5 404		19 912
TOTAL	9 723		36 689

Note: (1) Seed cotton

4.2 Crop Processing

Processing in the project will be limited to drying of the grain crops, rice and maize, and hulling rice. Although facilities for grain drying and rice hulling are being installed at Jamama and Gelib respectively (Section 1.4) the capacities proposed could not cope with the volumes of produce expected at Mogambo. Hence provision has been made in the project plan for installing these facilities. Although cotton ginning capacity will also be required it has not been considered necessary to provide for it in the project. Somaltex is currently considering three options regarding modfication and extension of the existing ginning facilities at Jamama (Section 1.4.1) and is likely to increase the overall capacity of the plant.

4.2.1 Crop Drying

The major drying requirement will be for the gu rice crop. The der maize crop should require little artificial drying as it will be harvested in the driest part of the year. A single drying plant with up to 30 t/h capacity is proposed. It would handle both the rice and maize crops and would be located at project headquarters. The drying process for rice would incorporate the following sequence of operations:-

(a) Reception of grain from the field in three concrete lined pits.

(b) Removal by conveyors and elevators to three hopper bottomed silos for pre-drying storage.

(c) Conveyed to pre-cleaners and then to a double flow moving bed grain drier.

(d) Conveyed from the drier to four hopper bottomed silos for cooling and tempering.

(e) After tempering the grain is returned to a second double flow drier from where it is conveyed to bulk storage on warehouse floors with ducts for ventilation.

The maize would only require one pass through the drier and therefore would by-pass the first stage drier and tempering silos. As the maize would not be stored on ventilated floors, the second drier would have a cooling fan which would be used with maize prior to storage.

The drying process would be monitored throughout.

4.2.2 Rice Hulling

Rice hulling would be carried out at an operating rate of 5 t/h for a nine month period between August and May. The mill would be sited adjacent to the rice store building. The process would comprise the following sequence of operations:-

(a) Removal from the store to four external silos.

(b) Conveyed to platform weigher unit and thence to the mill intake hopper.

(c) From the intake hopper the rice would pass through a cleaning unit with vibrating sieves and then into the husking unit.

(d) The final operation before 'sacking off' is grading into whole and broken grains.

4.2.3 Crop Storage and Processing Buildings

The general layout of the plant and buildings is shown schematically in Figure 4.1. The dimensions of the main buildings would be as follows:-

(a) Intake pit covered area: 12.2 m x 30.5 m x 5.5 m to eave height

(b) Drier area: 12.2 m x 12.2 m x 7.6 m to eave height

(c) Paddy store area: 36.0 m x 108.0 m x 5.0 m to eave height

(d) Rice mill area: 20.0 m x 36.0 m x 5.0 m to eave height

(e) Maize store area: 20.0 m x 48.0 m x 5.0 m to eave height

Since more of the gu rice crop will have been hulled and sold by mid-January there should be adequate capacity for storage of the der maize.

4.3 Seed Preparation

A seed preparation plant with facilities for cleaning, grading and dressing seed would also be associated with the headquarters crop storage and processing units, and would be located within the main rice storage shed. The plan would comprise a reception pit with elevator/conveyor to a cleaner from where it would be transferred to an indented cylinder type grader fitted with various screens for rice and maize seed. From the grader the seed would be transferred to a dressing unit where it would be dressed with Fernasan D powder. The final stage would be weighing and bagging prior to storage. A small plant for acid delinting of cotton seed would also be installed.

4.4 Other Buildings

4.4.1 General Stores

A main warehouse will be required for storage of incoming goods at project headquarters. A general purpose building some 60 m long by 18 m wide should be adequate for storage, office and toilet space.

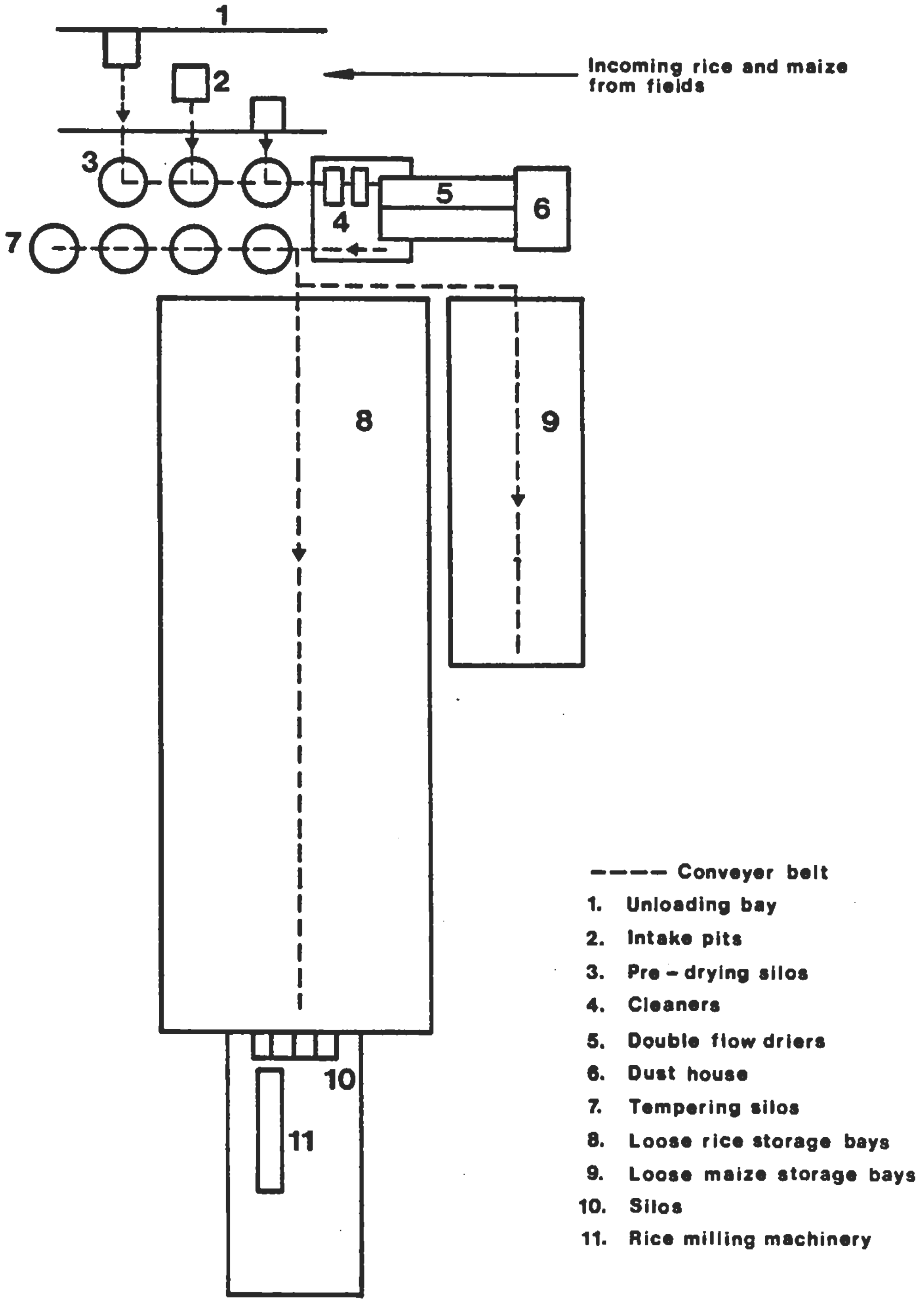
4.4.2 Workshop

The workshop would require a floor area of about 2 000 m^2. Details, including a layout plan, are given in Annex 5, Chapter 6.

4.4.3 Equipment

Most of the agricultural machinery and equipment will be permanently located at the four farms where provision has been made for its accommodation.

Grain dryer and rice mill layout



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CHAPTER 5

CROP WATER REQUIREMENTS

5.1 General

Calculations of water requirements have followed the methods set out in the FAO Paper Nr 24 Crop water requirements, by Doorenbos and Pruitt (1977).

These calculations are summarised in Tables 5.4 to 5.11 and discussed in more detail below. The cropping calendar is shown in Figure 5.1.

5.2 Evapotranspiration

The evapotranspiration value used by Doornenbos and Pruitt is a reference crop evapotranspiration (ETo) and it is recommended that this is calculated for use with their crop coefficients in preference to the Penman open surface evaporation. The calculation of the ETo value has been carried out using climatological data for Gelib and Ionte following the method described by Doorenbos and Pruitt. The results are summarised in Table 5.1.

TABLE 5.1

Reference Crop Evapotranspiration, ETo (mm)

Month	Gelib	Ionte	Weighted average	Design value
January	195	152	166	179
February	188	141	157	170
March	216	164	181	195
April	156	140	145	157
May	141	130	134	145
June	124	116	119	129
July	127	120	122	132
August	148	130	136	147
September	160	137	145	157
October	163	140	148	160
November	145	132	136	147
December	164	142	149	161
TOTAL	1 927	1 644	1 738	1 879

The average has been weighted in favour of the Ionte value which is nearer to Mogambo. It has been calculated from the Ionte value plus one-third of the difference between Gelib and Ionte values. The values of ETo used in the calculations of crop water requirements, the design values, have been obtained by multiplying the weighted average by 1.08 to allow for non-average climatic conditions.

5.3 Crop Factors

Crop factors depend not only on the crop itself but also on the variety, particularly its growth period, and also on the time of year in which it is grown. The method proposed by Doorenbos and Pruitt is based on dividing the growth period into four development stages:

(a) initial

(b) crop development

(c) mid season

(d) late season

each of which is assigned a proportion of the total days and each of which is allocated a crop factor. Variables such as wind speed, relative humidity and irrigation interval are taken into account in the method used to assess crop factors.

In order to determine monthly crop factors for each crop, the crop factor curves are plotted as illustrated in Figure 5.2 with one curve for the first planting and one for the last. Monthly average crop factors are then determined from the two curves.

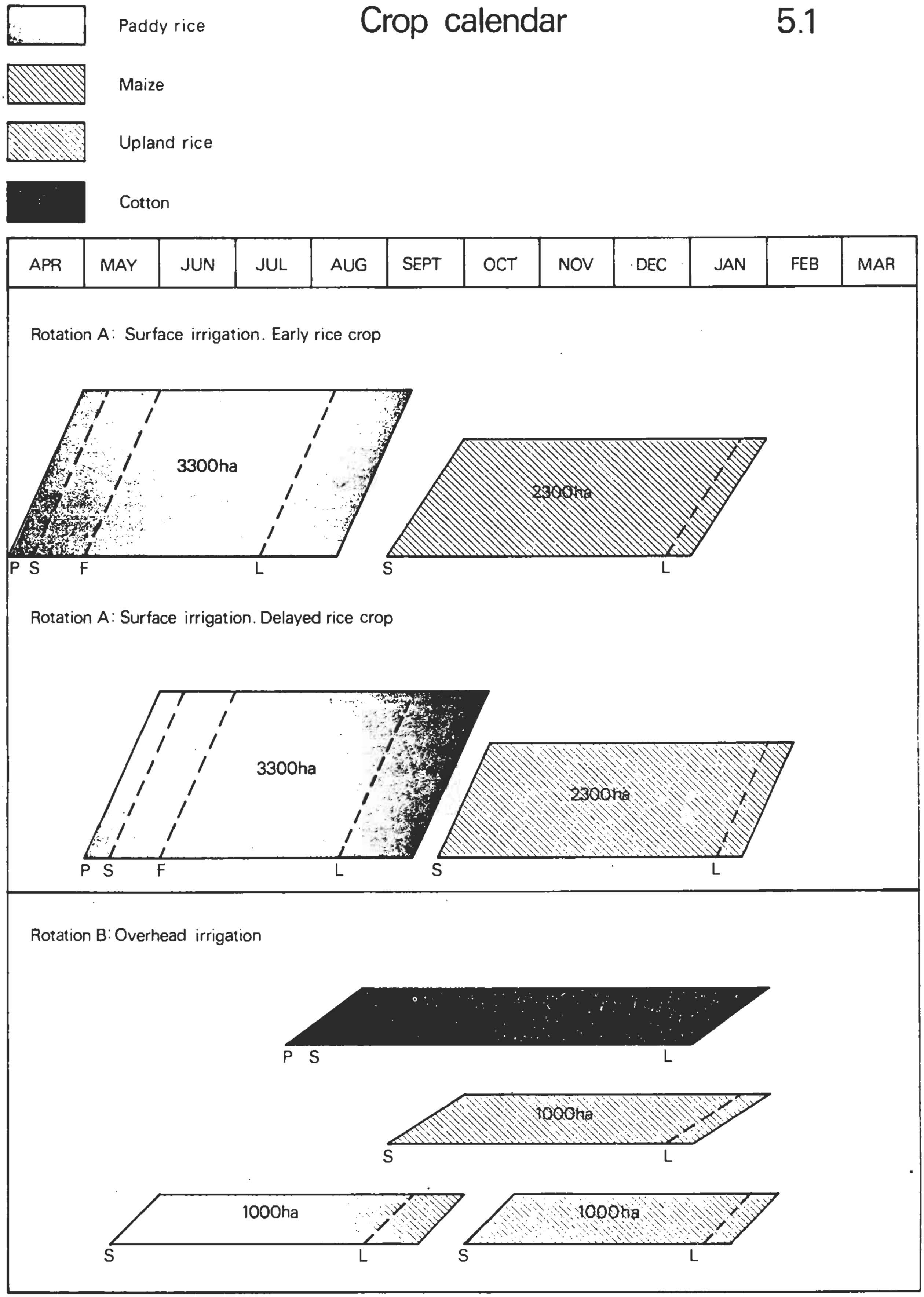
5.4 Effective Rainfall

The rainfall records for Jamama have been used to generate the monthly rainfall figures used to assess water requirements.

These records cover the years from 1929 to 1936, 1953 to 1958 and 1963 to 1965, a total of 17 years, of which nine are complete and eight have some months missing. The records for Jamama were the longest available records for a station near to the project area. Records are also available for Gelib and Kismayo but the annual rainfall totals for these stations are substantially different from that for the project area and these records were therefore not used in the analysis. No more recent records for Jamama could be located during the fieldwork.

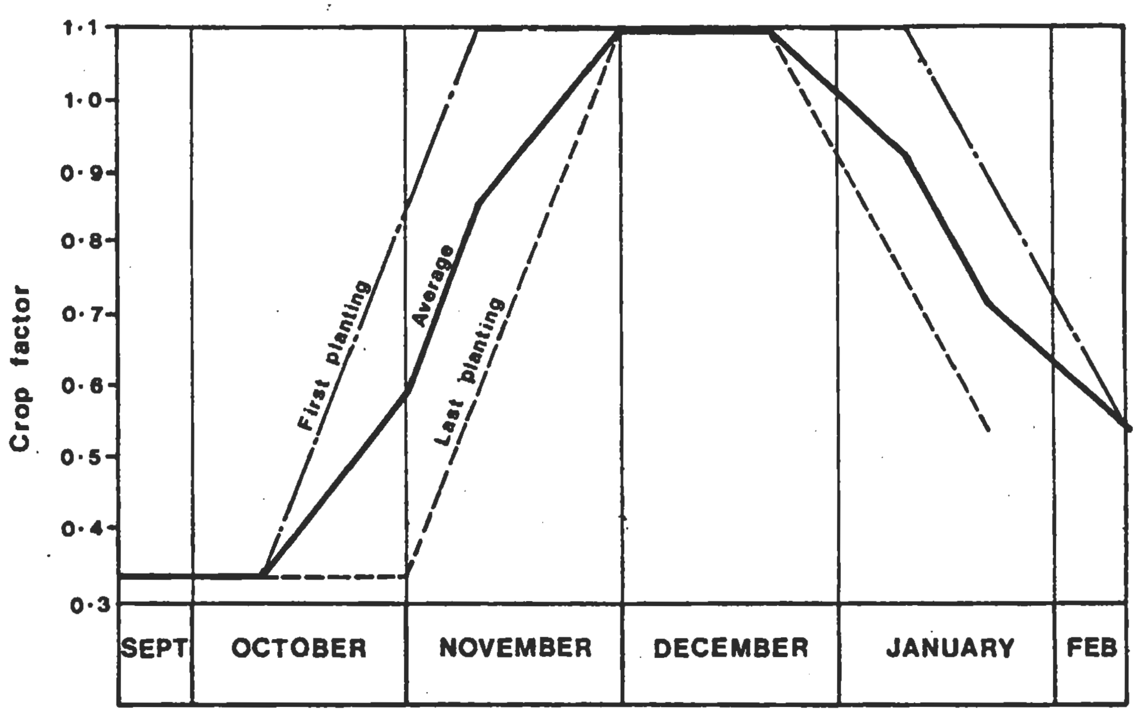
Two basic approaches are possible to obtain the 80% monthly rainfall figures, that is those values which have an 80% chance of being exceeded. The first method involves finding the annual rainfall for the 1 in 5 dry year and then dividing this figure into monthly values in proportion to the mean monthly values. However, this method generally gives monthly values which, when compared with the records for the month concerned, are exceeded much less frequently than four years in five. This is because the range in rainfall values in a given month is very high and occasional high values tend to add weight to the annual

Crop calendar 5.1



P – prewater S – sow F – flood (paddy rice only) L – last irrigation

Crop	:	Maize (der season). Late planting
Maturity period	:	120 days (20/30/40/30)
Planting stagger	:	20 days
Crop factor	:	initial - 0·33
		mid season - 1·10
		late season - 0·55



Average monthly crop factors :

September	0·33
October	0·42
November	0·89
December	1·08
January	0·82
February	0·56

TABLE 5.2

Crop Factors

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gu Season:												
Paddy rice (early)	-	-	-	1.10	1.10	1.10	1.00	9.95	-	-	-	-
Paddy rice (late)	-	-	-	-	1.10	1.10	1.10	1.00	0.95	-	-	-
Upland rice	-	-	-	-	0.90	1.00	1.10	1.00	0.95	-	-	-
Der Season:												
Cotton	0.76	-	-	-	-	-	-	0.30	0.49	0.86	1.08	0.99
Maize (early)	0.69	-	-	-	-	-	-	-	0.35	0.65	1.00	0.94
Maize (late)	0.82	0.56	-	-	-	-	-	-	0.33	0.42	0.89	1.08
Perennial:												
Bananas	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90

Note: * Constant average crop factor for bananas assumes planting dates staggered throughout the year.

TABLE 5.3

Monthly Rainfall Values for Jamama

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1929	-	-	-	-	-	-	111	15	95	72	49	91	-
1930	0	0	58	82	362	88	87	-	27	191	70	6	-
1931	0	0	1	0	215	41	-	-	-	21	3	0	-
1932	0	0	-	38	61	32	-	-	-	-	-	-	-
1933	12	0	0	70	26	62	94	26	23	0	0	0	313
1934	0	0	0	69	99	86	48	89	7	4	0	0	402
1935	0	0	0	34	23	141	41	25	8	4	16	32	323
1936	0	33	0	91	4	140	31	15	188	-	0	42	-
1953	-	-	-	-	8	111	146	41	0	0	0	0	-
1954	0	0	0	44	37	112	41	19	0	0	5	10	268
1955	0	0	0	86	224	50	77	0	0	0	0	0	437
1956	0	0	0	0	60	42	0	0	0	0	40	0	142
1957	0	0	0	82	116	74	72	11	0	0	43	39	437
1958	14	0	0	121	57	41	-	-	-	-	-	-	-
1963	0	0	47	92	110	77	37	36	145	5	93	104	745
1964	0	10	9	270	271	79	61	98	11	0	0	7	816
1965	0	0	0	9	-	-	-	-	-	-	-	-	-
Mean	2	3	8	73	111	78	65	31	39	23	23	24	431(1)

Values equalled or exceeded 80% of the time:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	0	0	0	19	24	41	37	9	0	0	0	0

Calculated effective rainfall:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	0	0	0	17	22	36	32	8	0	0	0	0

Notes: All values in mm
Missing value indicated by -
(1) Sum of monthly means = 480

average. The second method involves analysing each month in turn to find the 1 in 5 dry month so that this figure truly represents the value with an 80% chance of exceedence in that month. This second method has been adopted and the resulting design rainfall figures are shown in Table 5.3.

Effective rainfall is the amount of rainfall which can be considered to be used by a crop. Generally the lower the rainfall value the higher the percentage efficiency since less water is lost to run-off and deep percolation. The following percentage efficiencies have been adopted (Source: USBR).

Monthly rainfall (mm)	Percentage effective
0 - 25	90.0
26 - 50	87.5

Monthly effective rainfall values are given in Table 5.3.

5.5 Percolation Losses

The term 'percolation loss' refers to that part of an irrigation application which moves downwards through the soil and passes beyond the root zone and thus is not available to the crop. In flooded rice fields this is a continuous process spread approximately evenly over the whole basin. For the other irrigation methods it will occur as a result of uneven distribution of the irrigation water over the field.

Field infiltration tests were carried out as part of the soil survey work and the results are discussed in Annex 2. The results show a wide scatter and cannot be used to give a realistic estimate of the losses which will occur due to percolation beyond the root zone during irrigation. Particularly erratic results were observed on the basin soils where the heavy cracking characteristics of the soil inevitably give high initial values. The time scale of the tests and the fact that the soil surface is undisturbed means that cracks may not fully close during the test and the infiltration values observed are not therefore representative. Tests were carried out with the soil surface 'tilled' and these demonstrated a significant reduction in the infiltration rate.

Generally speaking none of the soils in the project area is any more than moderately permeable and the basin clays are described as relatively impermeable. It is reasonable to assume therefore that rice can be grown in these basin soils under paddy conditions although it is accepted that mechanical puddling of the soil surface may be necessary to keep percolation losses to a reasonable level.

For the purpose of assessing water requirements for the paddy rice, a loss to deep percolation of 5 mm/d (150 mm/month) has been assumed although in practice slower rates may well be achieved. Percolation losses for the crops grown under non-flooded conditions have been allowed for in the field efficiency terms described below.

5.6 Prewatering Requirement

The prewatering requirement is applied prior to sowing. It serves to facilitate the land preparation activities and also promotes weed growth so that this can be dealt with before drilling takes place. The depth of prewatering application required depends chiefly on the moisture content of the soil at the time and this will depend on the time of year and on how long before irrigation of the previous crop ceased.

Since none of the crops proposed follows closely behind the previous crop's final irrigation, the need for prewatering or initial watering is substantial and a minimum of 75 mm has been allowed. In the case of paddy rice, which follows the dry season when there is no cropping and which requires the soil to be saturated fairly early on in the growth cycles, a depth of 150 mm is appropriate. For the cotton crop, 125 mm has been allowed since the last irrigation before sowing will have taken place in the previous year, although it is recognised that sowing does take place at the end of the gu wet season when the soil moisture content may well be high.

5.7 Rice Flooding

The rice basins cannot be flooded until the seedlings have reached sufficient height to avoid being drowned. Ultimately a maximum ponded depth of 150 mm will be appropriate but it is neither necessary nor desirable for this depth to be achieved in one irrigation application. It is preferable that the final depth is reached after two or three applications, the increase in level following closely behind the development of the plants. For the water requirement calculations it has been assumed that the water depth is increased to maximum over a period of one month.

5.8 Irrigation Efficiencies

Irrigation efficiencies have been considered at two levels - conveyance efficiency and field efficiency. Conveyance efficiency has been allowed for in the seepage loss relationship used in the design of the main canal and distributary canals (see Annex 5). Field efficiencies vary with the system of irrigation and these are discussed in detail below.

5.8.1 Field Efficiency - Surface Irrigation

For the rice crop, which is grown under flooded conditions, percolation losses are allowed for separately and the field efficiency of 0.8 therefore includes only losses resulting from mismanagement and seepage from the unit channel. For the maize crop which follows the rice crop, the field efficiency term allows for all losses occurring after the unit channel head structure, including percolation, and therefore a value of 0.6 is appropriate. The field efficiency values assume a reasonable level of management but should not be difficult to achieve in practice. Adoption of the basin irrigation method with level basins has the advantage that losses resulting from poor supervision are low provided that the basin bunds are maintained and that operation of the siphon tubes is supervised.

5.8.2 Field Efficiency - Overhead Irrigation

Overhead irrigation lends itself to a more scientific approach to determining field efficiency since it depends much less on the human element. The losses which occur in a sprinkler system comprise:-

(i) leakage from hydrants and pipes

(ii) direct evaporation of water droplets

(iii) percolation losses resulting from uneven distribution of water

(iv) fringe losses.

Following the methods described in 'Design of sprinkler installations' by Baars and Kijne (1972) we can compute the overall efficiency as follows.

(a) Evaporation Losses

Assuming the following average climatic data (for night irrigation only):-

(i) average air temperature - 25^{o}C

(ii) average wind speed (at 2 m) - 0.5 m/s

(iii) average relative humidity - 80%

(iv) average pressure in sprinkler - 3.0 atmospheres

and taking a sprinkler nozzle diameter of 6 mm, an evaporation loss of 1.5% is obtained.

(b) Percolation Losses

Irregular distribution of the sprinkled water across the soil surface will result in water being lost to deep percolation in those areas which receive too much. The irregularity of distribution is a function of the spacing of the sprinklers, the quality of the nozzles, the application rate and especially the wind speed.

The evenness of the distribution of water across the land is generally expressed as a uniformity coefficient (Christiansen, 1942) which for zero wind conditions can be taken as 85% for a sprinkler and lateral spacing of 65% of the wetted diameter. The effect of wind speed on this coefficient has been assessed by Wiersma (1955) who suggested that the uniformity coefficient is decreased by 4% for every 1.0 m/s of average wind speed. Therefore for a maximum average night wind speed of 0.5 m/s the uniformity coefficient becomes 85 - (0.5 x 0.4) = 83%. It has been demonstrated (Walker, 1979) that if the application efficiency is taken as 83% (the same as the above calculated uniformity coefficient) this results in 20% of the area receiving less than the design water requirement. Higher efficiencies would result in a lower percentage of the area being underwatered.

Irregular distribution is also caused by the variation in pressure along the lateral which is estimated to give a loss of about 3%.

To summarise, the total losses are estimated at:

Evaporation	1.5%	
Percolation	17%	(1)
Fringe losses	2%	
Leakage	1%	
Irregular distribution along lateral	3%	
	24.5%	

Note: (1) Based on an average underwatered area of 20%.

It is recommended therefore that a field efficiency of 0.75 is assumed for the overhead irrigation.

5.9 Monthly Crop Water Requirements

Table 5.4 to 5.8 show the development of the crop water requirements for the rice, maize and cotton crops. The monthly values quoted are the net requirements with no allowance for any irrigation efficiencies. The method of calculation is as follows.

The evapotranspiration multiplied by the crop factor gives the consumptive use of the crop in millimetres for the month concerned. The effective rainfall is deducted from this figure and the result is multiplied by the average cropped area expressed as a fraction of the total area of the crop concerned. To this are added any prewatering, flooding (paddy rice only) and percolation (paddy rice only) requirements to give the monthly net requirements.

The calculation of average cropped area for each month is based on the time that the crop is being irrigated and this covers the period from the first irrigation (including any prewatering) to the application of the final irrigation. The drying out period between last irrigation and harvesting is not included. Where prewatering continues across two months, as for the delayed planting maize crop in Table 5.5, the requirement is divided between the months.

The flooding requirement for the paddy rice crop, which increases the ponded level up to a depth of 150 mm, is assumed to take place in one month. Percolation losses are only allowed for in the case of rice when the paddy fields are flooded.

The values obtained for crop water requirements are therefore 'area related' in that they do not represent the requirements for an individual field. The values reflect the fraction of the total area of the crop concerned which is being irrigated during the particular month. This method has been adopted since it is much easier to use these values to obtain the main canal flow requirement, as described in Section 5.11.

5.10 Variations to the Crop Calendar

5.10.1 Paddy Rice

It is assumed that the prewatering requirement for the rice crop will be applied as soon as water is available in the river following the first flush of saline water. In some years water will be available early in April, in others prewatering will be delayed until mid-April or even the end of April (see Annex 1). The delay in sowing the rice is not in itself a problem but it will tend to result in the following maize crop being delayed which may suffer a water shortage in late maturity as a consequence. However, this is unlikely to have a serious effect since water requirements at this time are generally low. It is also possible that the delay in the rice harvest might result in greater damage by birds.

Two alternative sowing dates for the rice have been considered, the early date being 10th April and the late sowing being 10th May. These are illustrated on Figure 5.1 and the changes to the net water requirements are given in Table 5.4 for the rice crop and Table 5.5 for the maize crop.

5.10.2 Bananas

Bananas have been considered as a possible alternative crop for the overhead irrigated areas when water supplies are perennial as a result of the construction of Bardheere dam. This is discussed in more detail in Section 5.12.

5.11 Irrigation Requirements

Details of irrigation requirements are included in this chapter for completeness. The derivation of the main canal flow is discussed in more detail in Annex 5, Chapter 4, but the results are given in Tables 5.9 to 5.11 herein.

Basically the main canal flows are derived by obtaining, for each crop in each months, the field requirement (mm) which is the net requirement divided by the field efficiency. These field requirements are then applied to the total area of each crop and the results added together for each month. The main canal discharge is obtained thence by adding in conveyance losses in the distributary canals, storage reservoirs and the main canal.

Table 5.12 shows the volumes of water required each month by each crop and compares these with river flow availability in 1980, 1985 and 1990 (details are given in Annex 1).

5.12 Effect of Bardheere Dam

The effect of the construction of the Barheere dam on the project will depend to a large extent on the timing of its completion compared with that of the Mogambo project. This is discussed in more detail elsewhere in this report. Changes to the cropping pattern which can be made with the advent of perennial water supplies are discussed below.

One significant change which can be made is the earlier planting of the paddy rice crop, thus permitting the incorporation of a longer maturing variety which would result in higher yields.

The other possible change considered is the introduction of bananas as a crop for the levee soils (overhead irrigation). This is considered to be feasible on up to 1 200 ha. These two options have been investigated and the resulting irrigation requirements are shown in Table 5.11. It can be seen that, as a result, the main canal design discharge would have to be increased to 7.25 m^3/s, based on the requirement for May. This is an increase of 11% and the main canal would have to be designed and constructed to carry the increased flow since a later increase in the canal capacity would not be practicable. The main pump station would also need to be designed to deliver the increased flow.

The distributary canals serving the banana areas would also have to be designed to carry an increased discharge. However, since the banana crop would not be rotated this would only affect a proportion of the canals and, if the banana area is located near the head of the main canal, only the upper reach of the main canal would be required to carry the higher flow.

The design of the sprinkler system is such that it can meet a maximum gross requirement of 232 mm in a month. For the banana crop, if planting is staggered throughout the year, higher requirements will be necessary on some areas at certain times of the year. This is because the peak crop factor of 1.10 could occur with the peak reference crop evapotranspiration of 195 mm (March), giving a net requirement of 215 mm or a gross requirement of 286 mm, which is 23% higher than design. The equivalent percentage increases for January and February would be 13% and 7%, all other months having lower requirements. This problem can be overcome with no change to the sprinkler system by staggering the planting of the bananas within units or blocks of units. This can be organised in such a way as to avoid small areas of the crop maturing simultaneously over the whole planted area.

TABLE 5.4

Crop Water Requirements - Paddy Rice

	Apr	May	Jun	Jul	Aug	Sep
Evapotranspiration, ETo (mm)	157	145	129	132	147	157
Effective rainfall, Re (mm)	17	22	36	32	8	0

(a) Sowing starting 10th April

	Apr	May	Jun	Jul	Aug	Sep
Crop factor	1.10	1.10	1.10	1.00	0.95	-
Consumptive use (mm)	173	160	142	132	140	-
Average cropped area[1]	0.22	0.94	1.00	0.78	0.06	-
Prewatering (mm)	150	-	-	-	-	-
Flooding (mm)	-	150	-	-	-	-
Percolation (mm)[2]	-	75	150	117	9	-
Net requirement (mm)	184	355	256	195	17	-

(b) Sowing starting 10th May

	Apr	May	Jun	Jul	Aug	Sep
Crop factor	-	1.10	1.10	1.10	1.00	0.95
Consumptive use (mm)	-	160	142	145	147	149
Average cropped area[1]	-	0.22	0.94	1.00	0.78	0.06
Prewatering (mm)	-	150	-	-	-	-
Flooding (mm)	-	-	150	-	-	-
Percolation (mm)[2]	-	-	75	150	117	9
Net requirement (mm)	-	180	325	263	225	18

Notes: (1) Cropped area based on that receiving irrigation. Last irrigation takes place three months after sowing.

(2) Deep percolation adjusted for average cropped area. Based on rate of 5 mm/d.

TABLE 5.5

Crop Water Requirements - Maize

	Sep	Oct	Nov	Dec	Jan	Feb
(a) Early planting						
Evapotranspiration, ETo (mm)	157	160	147	161	179	-
Effective rainfall, Re (mm)	0	0	0	0	0	-
Crop factor	0.35	0.65	1.00	0.94	0.69	-
Consumptive use (mm)	55	104	147	151	124	-
Average cropped area(1)	0.50	1.00	1.00	0.94	0.22	-
First watering	100	-	-	-	-	
Net requirement (mm)	128	104	147	142	27	
(b) Delayed planting						
Evapotranspiration, ETo (mm)	157	160	147	161	179	170
Effective rainfall, Re (mm)	0	0	0	0	0	0
Crop factor	0.33	0.42	1.89	1.08	0.82	0.56
Consumptive use (mm)	52	67	131	174	147	95
Average cropped area(1)	0.08	0.92	1.00	1.00	0. 67	-
First watering (mm)	50	50	-	-	-	-
Net requirement (mm)	54	112	131	174	98	-

Note: (1) Cropped area based on that receiving irrigation. Last irrigation takes place 10 days before harvest (or earlier if desirable).

TABLE 5.6

Crop Water Requirements - Upland Rice

	May	Jun	Jul	Aug	Sept
Evapotranspiration, ETo (mm)	145	129	132	147	157
Effective rainfall, Re (mm)	22	36	32	8	0
Crop factor	0.90	1.00	1.10	1.00	0.95
Consumptive use (mm)	131	129	145	147	149
Average cropped area [1]	0.33	1.00	1.00	0.92	0.08
First watering	75	-	-	-	-
Net requirement (mm)	111	93	113	128	12

Note: (1) Cropped area based on that receiving irrigation.

TABLE 5.7

Crop Water Requirements - Maize following Upland Rice

	Oct	Nov	Dec	Jan	Feb
Evapotranspiration, ETo (mm)	160	147	161	179	170
Effective rainfall, Re (mm)	0	0	0	0	0
Crop factor	0.35	0.70	1.03	0.80	0.57
Consumptive use (mm)	56	103	166	143	97
Average cropped area [1]	0.67	1.00	1.00	0.50	-
First watering (mm)	100	-	-	-	-
Net requirement (mm)	138	103	166	72	-

Note: (1) Cropped area based on that receiving irrigation.

TABLE 5.8

Crop Water Requirements - Cotton

	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Evapotranspiration, ETo (mm)	132	147	157	160	147	161	179
Effective rainfall, Re (mm)	32	8	0	0	0	0	0
Crop factor	-	0.30	0.49	0.86	1.08	0.99	0.76
Consumptive use (mm)	-	44	77	138	159	159	136
Average cropped area [1]	-	0.50	1.00	1.00	1.00	0.94	0.22
Prewatering [2]	42	83	-	-	-	-	-
Net requirement (mm)	42	101	77	138	159	149	30

Notes: (1) Cropped area based on that receiving irrigation. Last irrigation takes place 140 days after sowing.

(2) Prewatering requirement 125 mm adjusted to suit average cropped area.

TABLE 5.9

Summary of Irrigation Requirements

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Evapotranspiration, ETo (mm)	179	170	195	157	145	129	132	147	157	160	147	161
Effective rainfall, Re (mm)	0	0	0	17	22	36	32	8	0	0	0	0
Field requirements (mm)(1)												
Rotation A: surface irrigation												
Rice (3 300 ha)(2)	-	-	-	230	444	320	244	21	-	-	-	-
Maize (2 300) ha	45	-	-	-	-	-	-	-	213	173	245	237
Rotation B: overhead irrigation												
Rice (1 00 ha)(2)	-	-	-	-	148	124	151	171	16	-	-	-
Maize (1 000 ha)	96	-	-	-	-	-	-	-	-	184	137	221
Cotton (1 100 ha)	40	-	-	-	-	-	56	135	103	184	212	199
Maize (1 000 ha)	36	-	-	-	-	-	-	-	171	139	196	189
Main canal head flow (m^3/s)	1.13	-	-	3.18	6.54	4.95	4.13	1.57	3.31	3.75	4.74	4.76

Notes: (1) Field requirement = net requirement divided by field efficiency

(2) Effect of delayed planting of rice crop, caused by water shortage in April is shown in Table 5.10

(3) Rice grown under overhead irrigation is upland rice. Surface irrigated rice is paddy rice.

TABLE 5.10

Irrigation Requirements - Showing Effect of Delay in Sowing Rice Crop

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Evapotranspiration, ETo (mm)	179	170	195	157	145	129	132	147	157	160	147	161
Effective rainfall, Re (mm)	0	0	0	17	22	36	32	8	0	0	0	0
Field requirements (mm)												
Rotation A: surface irrigation												
Rice (3 300 ha)(1)	-	-	-	-	225	406	329	281	23	-	-	-
Maize (2 300) ha	163	-	-	-	-	-	-	-	90	187	218	290
Rotation B: overhead irrigation												
Rice (1 00 ha)	-	-	-	-	148	124	151	171	16	-	-	
Maize (1 000 ha)	96	-	-	-	-	-	-	-	-	184	137	221
Cotton (1 100 ha)	40	-	-	-	-	-	56	135	103	184	212	199
Maize (1 100 ha)	36	-	-	-	-	-	-	-	171	139	196	189
Main canal head flow (m^3/s)	2.24	-	-	-	3.61	6.14	5.27	5.06	2.37	3.88	4.48	5.26
Flow for early planting (m^3/s)(2)	1.13	-	-	3.18	6.54	4.95	4.13	1.57	3.31	3.75	4.74	4.76

Notes: (1) Rice sowing delayed by one month until 10th May because of lack of water in river.

(2) Figures from Table 5.9

TABLE 5.11

Irrigation Requirements - Option for Situation with Bardheere Dam

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Evapotranspiration, ETo (mm)	179	170	195	157	145	129	132	147	157	160	147	161
Effective rainfall, Re (mm)	0	0	0	17	22	36	32	8	0	0	0	0
Field requirements (mm)(1)												
Rotation A: surface irrigation												
Rice (3 300 ha)(2)	-	-	246	383	442	320	250	21	-	-	-	-
Maize (2 300) ha	45	-	-	-	-	-	-	-	213	173	245	237
Rotation B: overhead irrigation												
Rice (800 ha)(2)	-	-	-	-	148	124	151	171	16	-	-	
Maize (800 ha)	96	-	-	-	-	-	-	-	-	184	137	221
Cotton (1 100 ha)	40	-	-	-	-	-	56	135	103	184	212	199
Bananas (1 200 ha)	215	204	234	188	174	155	158	176	188	192	176	193
Main canal head flow (m^3/s)	1.96	1.10	4.43	6.25	7.25	5.62	4.86	2.30	3.53	3.97	4.53	4.76

Notes: (1) Field requirement = net requirement divided by field efficiency

(2) Rice grown on basin soils is changed to longer maturing variety

TABLE 5.12

Irrigation Requirements and River Flows (Mm^3)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rotation A: surface irrigation(1)												
Paddy rice (3 300 ha)	-	-	-	8.25	15.93	11.48	8.75	0.75				
Maize (2 300 ha)	1.13	-	-	-	-	-	-	-	5.33	4.33	6.13	5.93
Rotation B: overhead irrigation(1)												
Upland rice (1 000 ha)	-	-	-	-	1.61	1.35	1.64	1.86	0.17	-	-	-
Maize (2 000 ha)	1.43	-	-	-	-	-	-	-	1.86	3.51	3.62	4.46
Cotton (1 100 ha)	0.48	-	-	-	-	-	0.67	1.61	1.23	2.20	2.53	2.38
TOTAL	3.04	-	-	8.25	17.54	12.83	11.06	4.22	8.59	10.04	12.28	12.77
River flow(2) available at Mogambo in :												
1980	30	5	0	54(3)	267	179	262	464	502	640	549	173
1985	0	0	0	18(3)	211	102	192	404	418	528	446	83
1990	0	0	0	8(3)	196	81	174	389	396	497	419	55

Notes:
(1) Figures based on Table 5.9
(2) Figures from Annex 1, Tables 4.13 (a), (b) and (c) for 1 in 5 year return period without regulation by Bardheere dam
(3) Although river flow in April is generally sufficient in quantity to meet demand, in fact this flow usually occurs only at the end of April which will cause delay in planting the paddy rice.