SOMALI DEMOCRATIC REPUBLIC
STATE PLANNING COMMISSION

MOGAMBO IRRIGATION PROJECT

Supplementary Feasibility Study

Main Report

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AUGUST 1979

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Date: 3rd March 1980

The Director General
State Planning Commission
Mogadishu
SOMALI DEMOCRATIC REPUBLIC

Dear Sir

MOGAMBO IRRIGATION PROJECT
FINAL REPORT

With reference to your letter of approval dated 21.2.80 reference TU/M1/586/80 and in accordance with Section 4.2 of our Agreement for Engineering Services we have pleasure in submitting forty copies of the Final Report comprising:-

Main Report	-	One volume
Annexes	-	6 volumes
Plates	-	2 volumes and one album

Five copies of the report are being transmitted simultaneously to the Kuwait Fund for Arab Economic Development and the Kreditanstalt fur Wiederaufbau as required by the Agreement.

We should like to take this opportunity of recording our thanks and appreciation for the co-operation we have received from the Somali Authorities in carrying out this assignment.

Yours faithfully
SIR M. MACDONALD & PARTNERS LIMITED

C. D. Fielder

C. D. Fielder

cc Kuwait Fund for Arab Economic Development
Kreditanstalt fur Wiederaufbau

MOGAMBO IRRIGATION PROJECT

SUPPLEMENTARY FEASIBILITY STUDY

This report comprises the following volumes:-

Main Report	
Annex 1	Hydrology and Climate
Annex 2	Soils
Appendix to Annex 2	Soil and Land Class Maps
Annex 3	Agriculture
Annex 4	Livestock
Annex 5	Engineering
Appendix to Annex 5	Computer Analyses
Annex 6	Infrastructure and Institutions
Annex 7	Economics
Topographic Maps	Orthophotographs
Topographic Maps	Spot Height Overlays
Album of Drawings	

CONTENTS

CONTENTS (cont.)

CONTENTS (cont.)

LIST OF TABLES

LIST OF TABLES (cont.)

LIST OF FIGURES

LIST OF PLATES

LIST OF PLATES (cont.)

LOCATION OF PLATES

ACKNOWLEDGEMENTS

Sir M. MacDonald & Partners Limited wish to thank Hunting Technical Services Limited who carried out the agricultural and economic aspects of this study.

Thanks are also due to J.A. Story and Partners who carried out the topographical survey of the project area and produced the base mapping.

The preparation of this report would not have been possible without the help of the State Planning Commission and its staff, and many other agencies and ministries in Somalia, all of whom willingly assisted the study team in their researches.

SUMMARY

1. Background

The Lower Juba valley is one of the most promising areas in Somalia for the development of irrigated agriculture. There are already several established projects, particularly the banana plantations which have been in operation for many years. More projects, including the Mogambo irrigation project, are planned for the future. The climate of the area is tropical semi-arid and with only about 500 mm of rainfall annually, generally occurring in intense localised storms, the need for irrigation is obvious. All of these projects will make demands on the waters of the Juba river and already there are problems of water shortages in the months of February and March which effectively restrict the growing of perennial crops. However for most of the year there are no problems of water shortage. Indeed in October and November the problem is one of flooding as the river frequently overtops its banks, causing widespread damage.

The construction of Bardheere dam in the upper reaches of the Juba river would solve both the problem of water shortage and that of flooding since its large reservoir would effectively maintain flows within an acceptable range. Major development of the river basin is limited by these problems and clearly the construction of the dam will increase the profitability of development schemes by reducing the need for flood protection and by widening the range of crops which can be grown. The dam would also have a potential for hydro-power which would be of benefit to the valley.

The Mogambo project area is at present relatively unproductive. Much of the area is covered in bush and scrub and those areas which have been cleared and cultivated often produce poor yields as a result of the low standard of crop husbandry and the uncertainty of the rains.

Geographically the project area lies between the river on the east and the higher marine plain on the west. The project soils are basically alluvial in origin, falling into two broad classifications, the heavy basin clay soils and the lighter clay levee soils associated with an extensive old meander complex. The soils of the project area are suitable for irrigated agriculture and, with an appropriate selection of crops, the potential exists for intensive agricultural production. The topography of the area varies, being relatively flat on the basin clays and more undulating and incised in the levee soils.

There are currently a few hundred families farming in the area, generally with plots of several hectares and frequently on a part-time basis. The main crops are maize in the gu season (April to June) and sesame in the der season (October to December). Otherwise the local people are occupied in the banana plantations on both river banks or in the few small industries in the disrict such as the plastics factory and the cotton ginnery. The estimated population of the project area and the nearby villages is about 11 000.

There is a good surfaced road situated near to the eastern boundary of the project area which connects the port of Kismayo to the town of Gelib.

2. The Project

A preliminary feasibility study (TAMS/FINTECS, 1977) identified a net cultivable area of 6 260 ha and proposed crops of maize, rice, cotton, sesame, forage and pulses, irrigated by surface methods. A large livestock component, in the form of a feedlot, was also proposed.

In this Supplementary Feasibility Study the total net area identified is 6 400 ha. Th crops proposed have been selected to maximise returns, to make most use of the available land and water resources, and to reduce the need for imported crops. The selected crops are rice, maize, cotton and bananas. Bananas can only be incorporated in the cropping pattern when perennial flows in the Juba river are assured by the construction of Bardheere dam. It has been assumed that the earliest date for the completion of Bardheere dam is 1987.

Two systems of irrigation are proposed for the project. The heavy clay soils will have surface irrigation in level basins. These soils are most suitable for the cultivation of paddy rice and their topography is sufficiently flat to permit land levelling into horizontal basins. A total net area of 3 300 ha under surface irrigation is proposed.

The lighter levee soils are associated with an old channel complex and in these areas the topography is more broken. Consequently land levelling is not practicable as it would require large quantities of earth moving and would result in unacceptable depths of cut and fill, thus exposing less fertile, more saline soil layers. For these soils, overhead irrigation is recommended since this requires no land levelling and the network of existing natural drainage channels can be left relatively unchanged. A total net area of 3 100 ha will be irrigated under an overhead system.

Irrigation supplies for the project will be pumped from the Juba river and conveyed to the project area in a system of earth canals from which surface irrigation by gravity, and pumped overhead irrigation, will be possible. The peak irrigation requirement will be 6.5 m^3/s but this will increase to 7.25 m^3/s when the banana crop is introduced.

Flood protection works have been included to prevent flood damage to the project works. The existing flood relief regulator at Bulo Yaag will be rehabilitated and the channel will be re-formed and extended through the project area to discharge into the natural channel system on the western boundary. Flood bunds are required to the north and along the western boundary. These works will become largely redundant after the completion of Badheere dam but are essential in the interim period before flow regulation is provided by the dam.

Drainage of surface water from the project area will be by a system of shallow surface drains discharging into two main outfall drains on the eastern and western boundaries. Approximately 30% of the project area will require pumped drainage to ensure that low lying areas are not flooded following heavy rain.

The project will be operated as a state farm with a management hierarchy and a paid workforce of technicians, supervisors, clerks and skilled and unskilled labourers. The project proposals incorporate a number of benefits designed to attract and retain the necessarily large labour force. These include village community services, a piped water supply, extension facilities, an allotment of irrigated land for each family, and above average wage levels. Villagers will be expected to organise the construction of their own houses but will be provided with assistance and materials. The project will be divided into four farms of approximately equal size each with an associated village to house the farm workforce. In this way the resident labour force will be directly associated with the project. In addition there will be a project headquarters which will have a grain dryer and rice mill, a large workshop, stores, offices, houses for executive staff, a power station and a piped water supply. There will also be a village associated with the headquarters to house those workers not directly employed on the four farms. A headquarters farm for trials, training and seed multiplication, and an airstrip have also been included. The villages and the headquarters will be linked by a primary road and this road will also connect with the existing main Kismayo - Gelib road.

The fairly intensive cropping calendar proposed will require timely agricultural operations because otherwise the cropping programme will be delayed, with a consequent reduction in yields. This is particularly the case in the period before the implementation of Bardheere dam when the irrigation of crops must be confined to nine months of the year. For example, the paddy rice crop on 3 300 ha, which will be sown in April and May, must be harvested in a period of not more than six weeks so that the subsequent maize crop can be sown early enough to ensure the availability of irrigation water throughout its growth period. In view of these restraints, and also because the availability of labour in sufficient numbers cannot be guaranteed, most of the agricultural operations will be mechanised. Mechanised operations include primary cultivation, sowing (rice, maize and cotton) and harvesting (rice and maize). Aerial spraying of herbicides and insecticides is also proposed with back-up spraying by hand. Manual harvesting of bananas and cotton is proposed but a trial area of 100 ha of narrow-row cotton has been included for which mechanised harvesting using a 'stripper' harvester will be investigated. This trial is recommended so that the feasibility of a system of mechanised cotton harvesting in Somalia can be tested.

A possible livestock feedlot as part of the project has been investigated in detail and subjected to economic analysis. Its inclusion in the project is not recommended in view of its poor economic returns, but some of the crop residues from the Mogambo project could be used for feedlot rations, possibly for the Trans-Juba livestock project.

3. Project Economics

The recommended project has an economic internal rate of return of just over 9%, with the Somali shilling shadow priced to its true open market value. This assumes that Bardheere dam is providing regulated perennial flows by 1987 so that bananas can be included in the cropping pattern.

The capital costs for the recommended project are given in the table below.

Summary of Project Capital Costs
('000 SoSh)

Item	Local currency	Foreign currency	Total	
Land preparation	12 859	12 858	25 717	(27 261)
Irrigation and drainage system	52 398	104 482	156 880	(178 567)
Buildings and services	19 812	40 202	60 014	(72 065)
Operation and maintenance vehicles and machinery	1 218	10 961	12 179	(14 006)
Agricultural machinery	3 628	32 656	36 284	(36 284)
Engineering design and supervision	6 525	12 115	18 640	(18 640)
Physical contingencies	8 507	15 754	24 261	(27 790)
TOTAL	104 947	229 028	333 975	(374 613)

Note: Costs are 1979 economic costs and do not include taxes and duties. Financial costs are shown in parentheses.

In order to make the recommendations given in this report, a total of six project options were investigated and analysed. These are described briefly below and the internal rate of return (not shadow priced) is given for each case.

(a) The Base Case

This case was formulated with the possibility that Bardheere dam will not be constructed in time to have a significant effect on the project. Perennial crops have not therefore been included and full flood protection works are required. Construction of the project works would start in 1981 and full implementation would be achieved by 1985. The net irrigable area is 6 400 ha, with 3 300 ha under surface irrigation (3 300 ha rice in the gu season, 2 300 ha under maize in the der season) and 3 100 ha under overhead irrigation (1 000 ha rice in the gu season, 1 100 ha cotton and 2 000 ha maize in the der season).

This case showed an economic internal rate of return of just over 3%.

(b) Case 2

In view of the higher costs of the overhead irrigation system a project including only those areas which could be irrigated by surface methods was investigated. By incorporating some of the marginal areas a total net area of 3 600 ha was identified. The crops would be paddy rice (3 600 ha) followed by maize (2 500 ha). Full flood protection works would be necessary.

This case gave a rate of return of just over 4%.

(c) Case 3

This is as case 2 but delayed until after the construction of Bardheere dam so that no flood protection works are required. Construction would commence in 1986 and full implementation would be achieved by 1989.

The rate of return at 4.2% is only marginally better than that for case 2.

(d) Case 4

This is as the base case, but delayed until after the completion of Bardheere dam and including 1 200 ha of bananas in place of 1 000 ha maize and 200 ha of rice/maize on the levee soils. No flood protection works are needed. Construction would start in 1986 and full implementation would be achieved by 1990.

This option showed a rate of rturn of 6.2%.

(e) Case 5

This is as case 4 except that the development is phased. The surface irrigated areas would be implemented first, starting in 1981, and development of the overhead irrigated areas would be delayed until 1986. Full flood protection works would be required.

This case gave a return of 4%.

(f) Case 6

This is the recommended option. It is implemented exactly as the base case but includes a changeover to bananas on 1 200 ha of the levee soils when perennial flows are available from Bardheere dam. The bananas would replace 1 000 ha of maize and 200 ha of upland rice/maize, and the first banana crop of 450 ha would be planted in 1987.

This is the preferred option, having one of the highest rates of return (just under 5.4%) and it can be implemented at the earliest opportunity.

4. Conclusions

The Mogambo irrigation project is probably one of the most promising developments in the Lower Juba valley. It is located close to the source of irrigation water and is ideally placed near to the district centre of Jamama and the port of Kismayo. There are no major constraints to its development although the need for overhead irrigation, flood protection and pumped drainage have tended to increase the estimated cost of development. The engineering works required, excluding infrastructure, have an estimated cost of SoSh 32 200 per hectare which is comparable with similar schemes elsewhere (equivalent to US $ 5 350 per hectare.

Bardheere dam, when constructed, will permit the introduction of the more profitable perennial crop of bananas and will obviate the need for flood protection works. It will also allow more flexibility in the cropping calendar for the project.

It should be noted that, if the planned rate of development for the Juba valley goes ahead without the implementation of Bardheere dam, by 1990 there will be a severe shortage of water in most years for the months of January and April as well as the present 'dry' months of February and March. This would further limit the period available for irrigation at Mogambo, making timing of the agricultural operations more critical, and would result in severe problems for other projects which include perennial crops, particularly those located in the lower reaches of the river. It is therefore recommended that the implementation of Bardheere dam is started as soon as possible.

It is also recommended that a Juba Valley Development Authority is set up in the immediate future so that further development in the valley can proceed in a controlled and co-ordinated manner.

Introduction 1

CHAPTER 1

INTRODUCTION

1.1 Project Location

The project takes its name from the village of Mogambo which is located on the right bank of the Juba river approximately 70 km by road from the coastal town of Kismayo. The project covers a gross area of some 8 000 ha in a strip of land about 16 km long and 5 km wide. Boundaries of the project area to the east and south are formed by existing banana plantations adjacent to the river. To the north is the Trans-Juba livestock project and the southern end of the Juba Sugar project proposed area. The western boundary of the Mogambo project is formed by a series of interconnecting old channels on the edge of the marine plain. The southern end of the project area is just 20 km from the coastline. The district centre town of Jamama is located on the opposite (left) bank of the Juba river.

Figure 1.1 shows the general location of the project in Somalia and Figure 1.2 shows the extent of the project study area which covered almost 15 000 ha of land between the river and the marine plain.

The Mogambo project is one of several irrigation projects scheduled for development in the Juba valley, some of which are in the implementation phase and all of which will ultimately draw on the finite water resource embodied in the Juba river.

1.2 Terms of Reference

The project has already been the subject of a feasibility study, carried out by Tippetts-Abbett-McCarthy-Stratton of New York and Financial and Technical Services of Cairo (TAMS/FINTECS), for which the final report was submitted in May 1977. It was decided subsequently to initiate a supplementary study, the Agreement for which was signed on 20th December 1978. Fieldwork for the supplementary study comenced in January 1979.

The principal tasks included in the terms of reference for the supplementary study are summarised below:

(a) Undertake a topographical survey of the whole project area and beyond its boundary, by up to 500 m where necessary.

(b) Carry out a semi-detailed soil survey of the project area including comprehensive in situ and laboratory analyses of soil and water samples.

(c) Review the hydrology of the Juba river with particular regard to the low flow periods and project flooding and the influence of Bardheere dam on the project.

(d) Carry out a preliminary design of the irrigation and drainage system including layout drawings, canal and drain longitudinal and cross-sections, flood protection details, pump station design, typical structure drawings and preliminary details of project infrastructure.

(e) Review the TAMS/FINTECS proposals for cropping pattern and the technical and economic aspects of the livestock component.

(f) Make recommendations about the organisation and management of the project and draw up an implementation schedule.

(g) Prepare detailed cost estimates for the works and carry out economic and financial analyses.

The purpose of the study has been to define the project in sufficient detail to enable an accurate assessment of the project economics to be made, so that subsequent negotiations for financing can proceed on a firm basis.

In this supplementary study, constant references to the TAMS/FINTECS study have been avoided so that the report can be read as a complete document. However, in view of the significant differences between the two studies, particularly with regard to costs, discussion has been included in the relevant Annexes to clarify the reasons for these differences.

The fundamental reason for the difference in cost estimates between the two studies is considered to be that the TAMS/FINTECS study lacked sufficient engineering detail to enable a realistic cost estimate to be made. However, the following major changes recommended in this supplementary study are also of significance:

(a) Reduction in cropping intensity (200% proposed by TAMS/FINTECS) and revised cropping patterns. See Annex 3.

(b) Introduction of overhead irrigation. See Annex 5.

(c) Inclusion of pumped drainage. See Annex 5.

(d) Night storage proposed for surface irrigation. See Annex 5.

(e) Much more comprehensive flood protection works. See Annex 5.

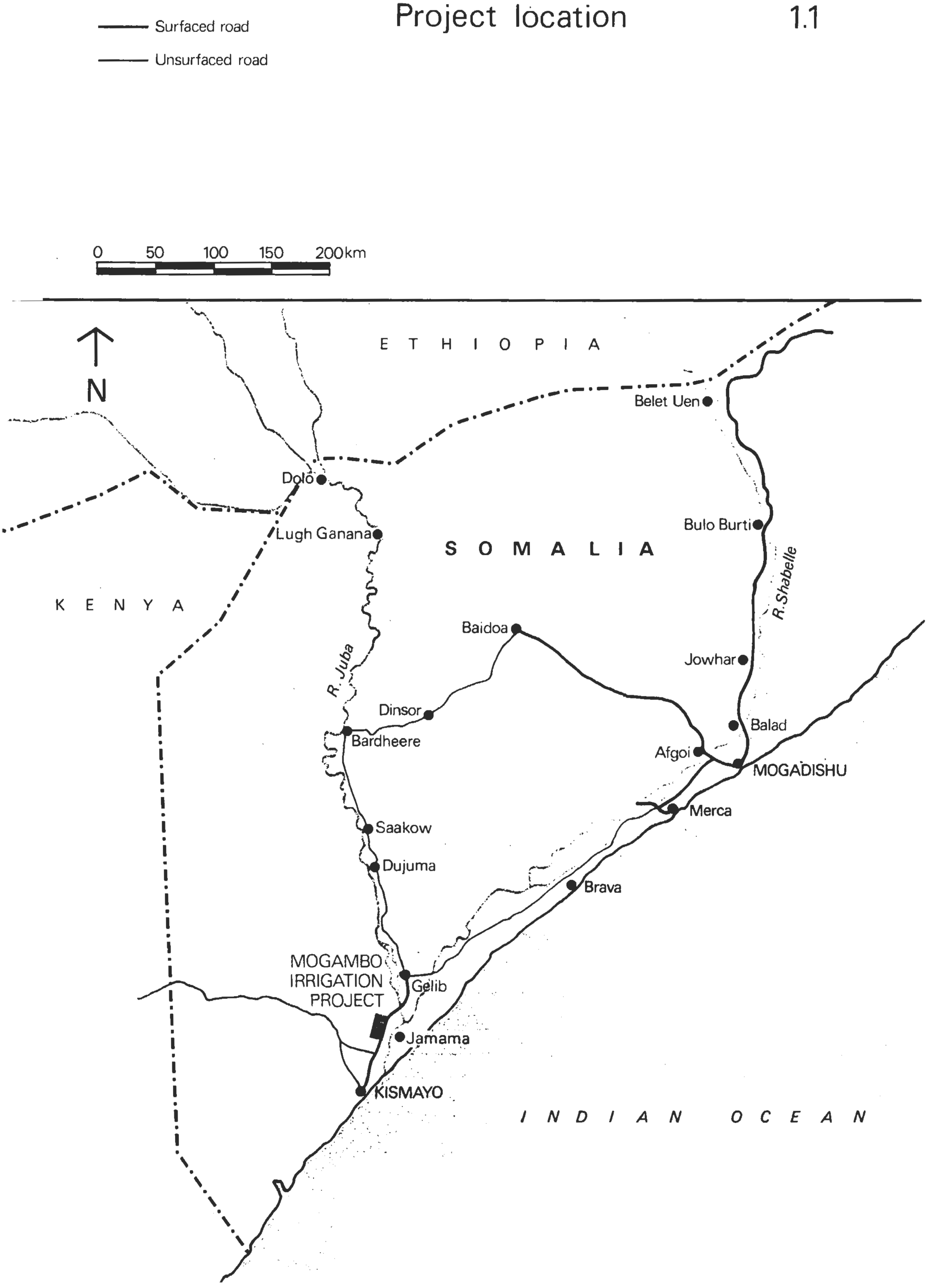
(f) No livestock component. See Annex 4.

In addition, some of the rates used by TAMS/FINTECS in preparing the cost estimate are considered to be underestimated.

In the study of the Juba river hydrology (Annex 1) full use has been made of all available data, including some relevant information subsequent to the TAMS/FINTECS study. It is considered that the conclusions drawn in Annex 1 are the best estimates possible, given the available data. Comments on the TAMS/FINTECS study have not been made in this Annex because generally it was assumed in that study, that river flow regulation by dams at Bardheere and Saakow would alleviate the problems of flooding and water shortage.

The TAMS/FINTECS soil survey and land classification was not sufficiently detailed and, since a completely new survey was required for the supplementary study, no reference to the previous study has been made in Annex 2 of this report.

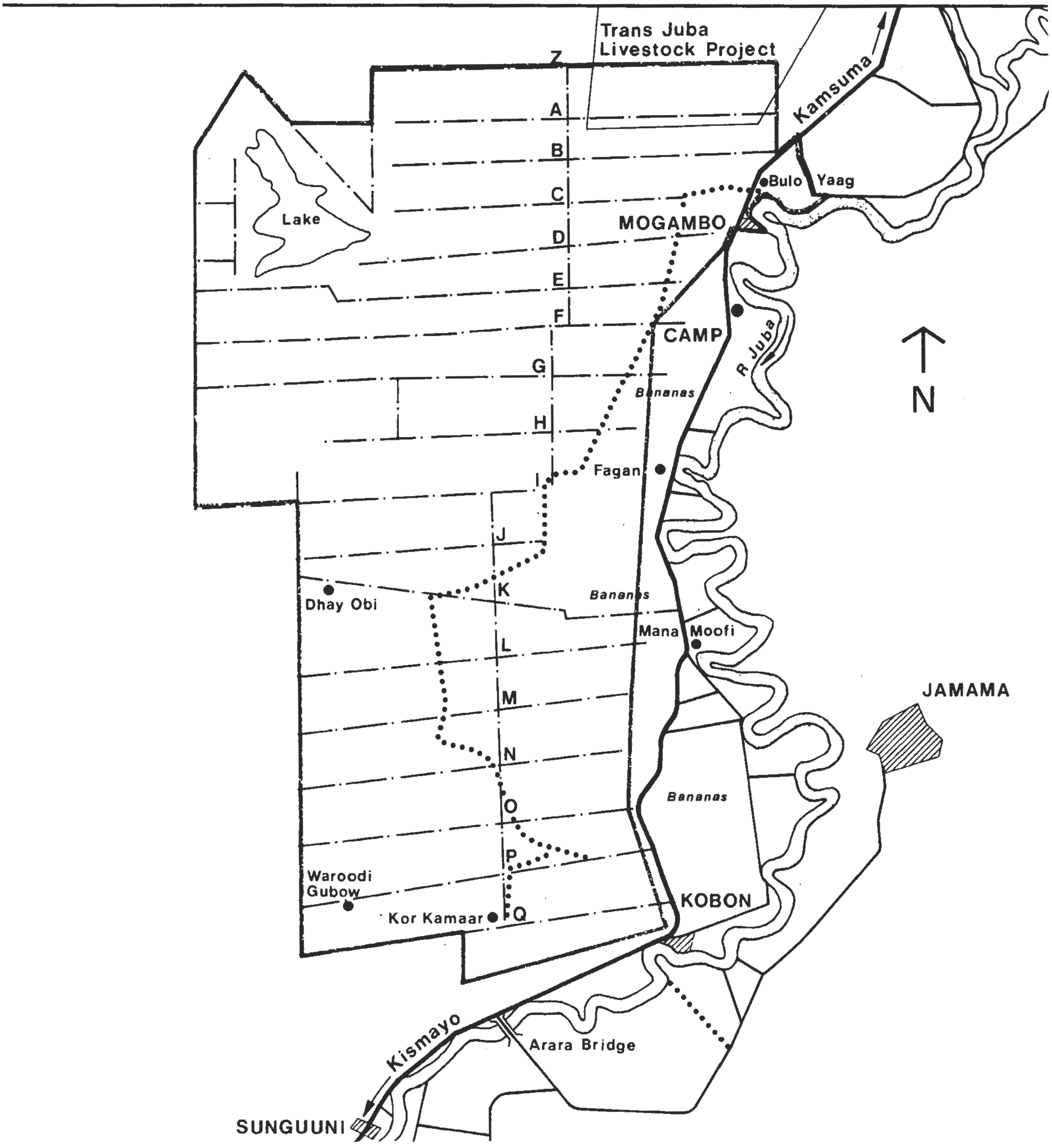
Project location



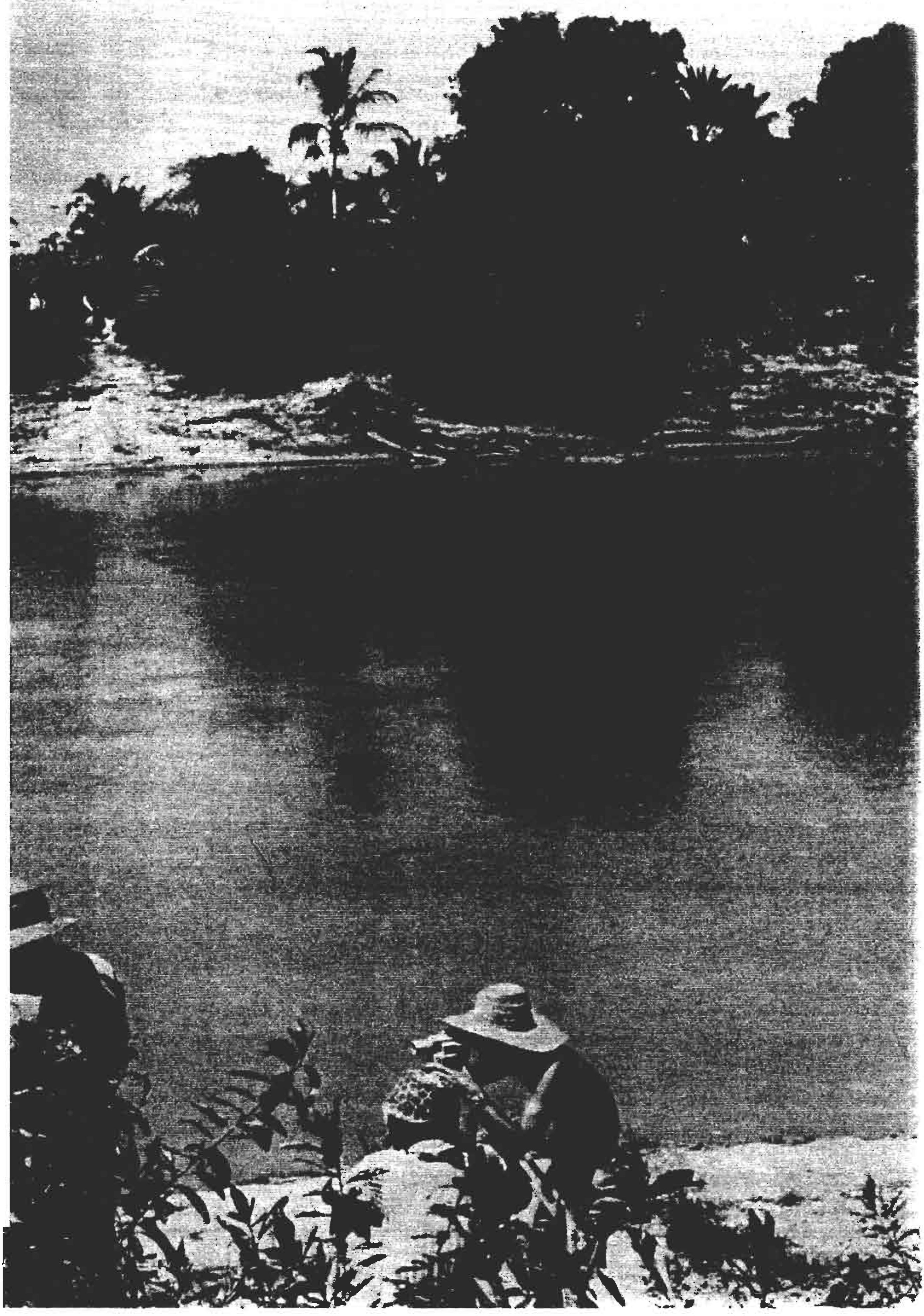
Project study area 1.2

Surfaced road
Bund
H Survey traces
Study area boundary

0 1 2 3 4 5km



Physical Resources 2



CHAPTER 2

PHYSICAL RESOURCES

2.1 Climate

The climate of the project area is tropical and semi-arid. The year is divided into four seasons which are defined approximately as follows:

gilal	January to March
gu	April to June
haggai	July to September
der	October to December

The gu season is the wettest time of the year but the rains are unreliable and storms tend to be very localised. Monthly average rainfall values hide the true picture. For example, the rainfall in April can vary between zero and 270 mm, and even in May there are years when as little as 4 mm has been recorded. The gu season rains are often extended through the haggai season to the der season rains but again rainfall is very unreliable. There is generally very little rain in the gilal dry season. The average annual rainfall based on 17 years records for Jamama is 480 mm but this is reduced to 431 mm if only those years for which there are full records are considered.

Air temperature rarely exceeds 35°C and infrequently drops below 20°C. Monthly variation of temperature is not significant but generally April is the hottest month with an average temperature of 29.4°C and August is the coolest with an average of 26.1°C. Monthly averages of relative humidity vary very little throughout the year, the annual average being about 77%.

The monthly mean values for various meteorological parameters are given in Table 2.1.

Wind velocities in the vicinity of the project can be quite strong in the daytime but during the hours of darkness winds are very light. Wind speeds of more than 6 m/s at a height of 2 m are common between dawn and dusk.

All relevant climatological data used in the preparation of this report are summarised in an appendix included in Annex 1.

2.2 Soils

The Juba flood plain is formed of alluvial material of variable particle size distribution brought down by the Juba and Shabelle rivers since the late Tertiary period, and several hundred metres of Tertiary and Quaternary deposits have been laid down. The Juba river is set slightly below the surrounding flood plain indicating a recent change or lowering of base level during the Pleistocene era.

The flood plain is flat with a sub-parallel surface drainage network. Several landforms can be recognised within this flood plain including terraces, channel remnants, levees, meanders, oxbows, and slackwater depressions. The most

TABLE 2.1

Meteorological Means

Parameter	Units	Station	Month											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	mm	Jamama	2	3	8	73	111	78	65	31	39	23	23	24
Maximum temperature	^{o}C	Jamama	33.2	34.0	33.4	34.2	33.4	31.8	30.0	30.9	32.0	32.9	33.0	33.5
Mean temperature	^{o}C	Jamama	28.5	28.9	28.6	29.4	28.5	27.1	26.1	26.1	26.8	27.7	28.0	28.4
Minimum temperature	^{o}C	Jamama	23.9	23.9	23.8	24.7	23.6	22.3	22.2	21.4	21.7	22.6	23.1	23.3
Relative humidity	%	Ionte	74	74	74	76	79	80	81	78	78	77	76	76
Sunshine duration	hours /day	Alessandra	9.2	9.0	10.0	7.6	7.6	6.9	7.0	7.9	8.5	7.5	6.7	8.2

Sources of data:
1. Contributo alla Climatologia della Somalia, Fantoli
2. Inter-riverine Agricultural Study, Hunting Technical Services

prominent feature is the semi-continuous old channel course occupying the western part of the area. This is associated with many of the features indicated above and is formed from somewhat older alluvial material than that found to the east.

Macro-relief is dominated by the old channel courses or fartas which are often water filled. Most of the area is relatively flat with the only abrupt changes of slope being into the fartas and onto the marine plain. Micro-relief is more significant with considerable areas of gilgai developed in the clay soils on the eastern side of the old alluvial flood plain. Termite mounds are common especially on the medium textured levee soils.

The vertisols of the Mogambo area have a distinctive morphology which influences their tillage characteristics, soil water relationship, chemistry and fertility. The expanding lattice (montmorillonite) clays of the vertisols have the capacity to expand and contract on wetting and drying respectively. In the dry state the soils develop a shallow friable mulch and vertical cracks to a depth of at least 0.5 m. These cracks separate the structural units and some of the friable surface is washed down the cracks. When the soil is rewetted and expands, pressure develops in the lower horizons giving rise to a churning effect in the whole profile. This effect is reflected in the development of slickensides or slip faces and wedge shaped structures in the subsoil and gilgai micro-relief. The soils have significant variations in structure ranging from course hard prismatic peds when dry, to sticky and plastic when wet, with considerable structural disintegration.

The non-vertisolic soils, laid down adjacent to the old channel courses, have a high percentage of fine sands and silts, which is reflected in the widespread capping of these soils.

The soils are highly calcareous and base saturated. Salinity levels are generally low in the topsoils but increase with depth to higher levels in the subsoil. High levels of exchangeable sodium are only encountered in the depressional areas.

2.3 Water Resources

The Juba river has considerable potential as a source of irrigation water for agricultural development projects. There are perhaps three main constraints to the development of this source:-

(a) The lack of a unifying authority responsible for the development of water resources in the Juba valley.

(b) A shortage of water in the river during the months January to April.

(c) A tendency of the river to flood, especially during the months October and November.

The need for a Juba River Development Authority is already recognised and will be the subject of a forthcoming study. The problems of water shortages and flooding can both be virtually eliminated by the construction of the proposed Bardheere dam, which could be completed as early as 1987. Otherwise the waters of the Juba are ideal for irrigation use, although irrigation schemes must incorporate provisions for desilting since the suspended sediment load in the river can be quite high.

As has been mentioned in Section 2.1, rainfall in the project area is low (around 500 mm average) and is also irregular and inconsistent. Rainfall cannot be relied upon as a primary source of crop water requirements but it will of course supplement irrigation supplies.

The available data on groundwater in the area are very limited. The nearest deep wells are just north of Mogambo in the Trans-Juba livestock project. There are two wells here, each about 80 m deep, producing water with a conductivity of 1 500 to 2 000 micromhos/cm. Shallow wells in the project area also tend to have water with high conductivity readings. Groundwater cannot therefore be considered as a viable source of irrigation supplies without a well drilling and testing programme in the project area.

2.4 Materials

There are several possible sources of materials for construction including materials suitable for road pavement, stone pitching and concrete aggregates. Some of these sources are currently being exploited, a major user being the Juba Sugar project. Others have not been mined yet but have been identified as possible future sources which could be investigated more fully nearer the construction phase.

Table 2.2 summarises existing and possible future sources of material. The list of sources is by no means complete and further investigation will be necessary to determine the locations of other promising deposits. Further investigation into the quality of the materials is also required.

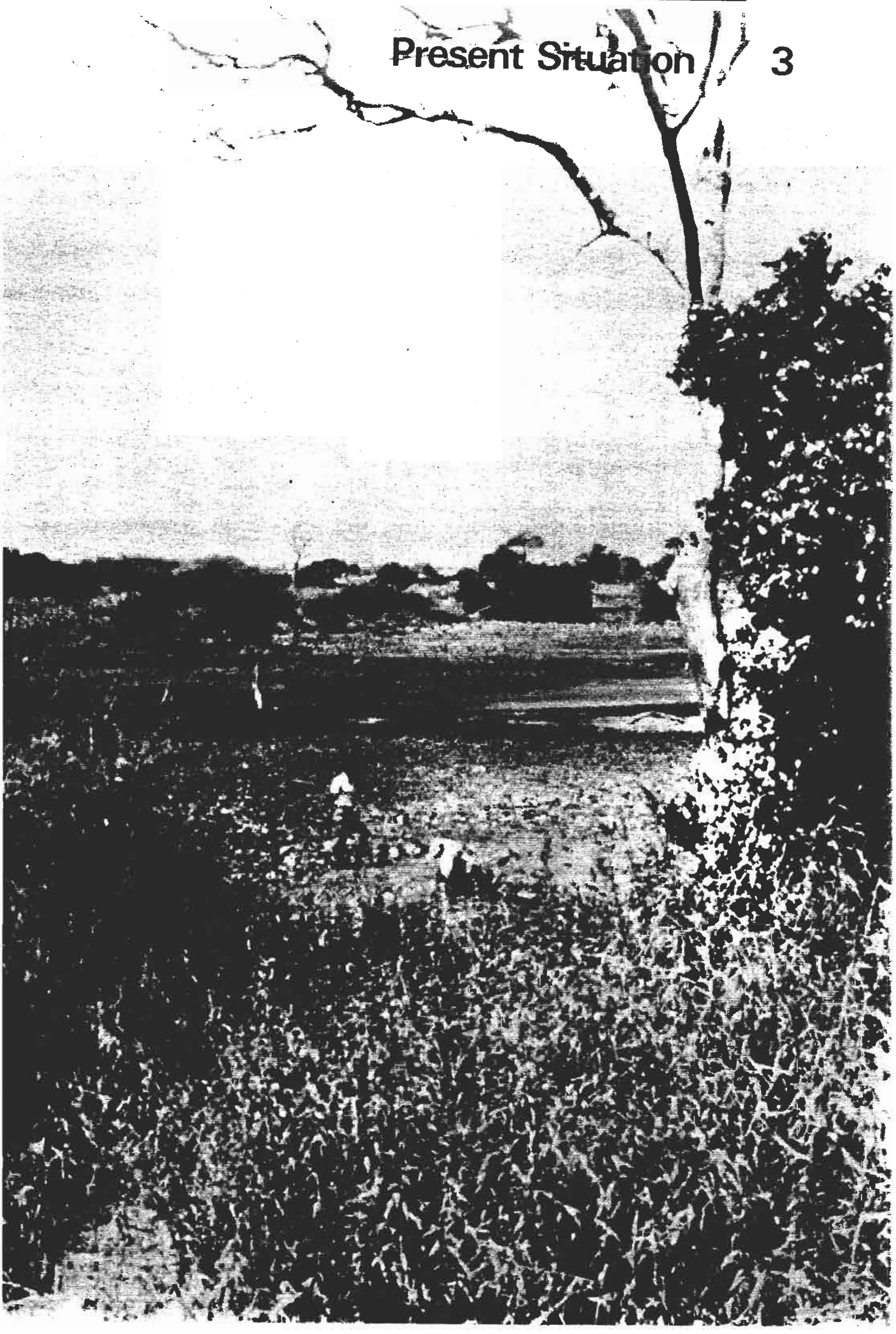
Generally speaking the local rocks are rather weak carbonate sandstones, limestones and marls. There are also stronger limestones which are commonly referred to as coral and which are red and grey in colour. From the various sources it will be possible to select materials suitable for dry stone pitching, concrete aggregate (crushed rock) and road surfacing. For fine aggregates there are deposits of beach sand and also the red coloured beach remnant sands.

TABLE 2.2

Sources of Construction Materials

Location	Materials	Quality	Status	Access from project area
Kismayo area	Rock (for stone pitching) Crushed rock aggregate Beach sand	Fair Fair Good	Currently worked	Approximately 60 km by surfaced road.
Bulo Gaduud	Road sub-base material	Fair. May be good enough for stone pitching	Has been worked in the past	Approximately 25 km by surfaced road.
Torda	Rock and aggregate	Poor	Currently worked	Approximately 15 km by surfaced road plus 7 km by unsurfaced road.
South of Torda	Rock Sand	Good Not known	Not yet worked	As Torda plus 5 km more surfaced road.
Arara bridge (near plastics factory)	Sand	Good	Not yet worked	Approximately 10 km by surfaced road.
South of Ionte (4 km north of Goob Weyn)	Rock	Possibly good	Not yet worked	Approximately 45 km by surfaced road.

Present Situation 3



CHAPTER 3

PRESENT SITUATION

3.1 Other Projects

There are only two river systems in Somalia, the Juba and the Shabelle, and these are major centres for agricultural development in the country. The water resources of the Shabelle are already highly utilised and there is little scope for further development. On the other hand the resources of the Juba valley have been under-utilised in the past and this area now presents the most attractive future development area. Already there are several projects in the preliminary stages of construction and implementation and there are others which are at feasibility or design stage. A list of these projects is given in Table 3.1 with brief details of each.

At present there is little or no co-ordination of the projects in the Juba valley even though, in the near future, severe shortages of water during the low flow months of January to March will inevitably result in lost production. Furthermore, project co-ordination is not only needed for the allocation of water resources, but there is an obvious need for co-ordination and co-operation across the whole spectrum of agricultural development including operation and maintenance of machinery, seed production, crop spraying, crop processing and product marketing. These operations have already been organised to some extent and administrative bodies such as ADC and ONAT have been set up for this purpose. However, the extent of future development will severely tax these organisations unless steps are taken now to improve and expand them.

It is understood that there are proposals for a Juba Valley Development Authority and this is currently the subject of a study. The setting up of such an authority is clearly of fundamental importance to the development of the Juba valley land and water resources.

One proposed construction project which will have a significant effect on the development of the Juba valley is Bardheere dam. This dam, as it is currently envisaged, will provide sufficient storage to maintain perennial flows in the river and, at the same time, will regulate high flows so that the risk of flooding is reduced to an acceptable level. There are also proposals to generate hydro-electric power at the dam. However, at the present time there are no funds made available for this project and even if these are made available in the near future, it is unlikely that the dam could be completed before 1987.

3.2 Land Tenure

The general principle that all land is state owned was enunciated in 1969, though it was not until 1975 with the Land Registration Law that legislation relating to land holding and use was actually codified. Under this law, private individuals and institutions are permitted to hold and use land and to dispose of it in accordance with customary practices, subject to certain provisions. If a land user wishes to secure his right of usufruct, he may register his right, subject to approval by the Ministry of Agriculture. If, however, his land is needed for the state or for state approved projects, his right would cease, in exchange for compensation for any immovable asset which he had placed upon the land. His right would also automatically be extinguished if he failed to use the land for a period of two years after registration.

TABLE 3.1

Irrigation Projects in the Juba River Valley

Project	Estimated project area (ha net)	Crops	Status at May 1979	Notes
Saakow	25 000	Rice, maize, sesame, cotton, groundnuts etc.	Preliminary design phase	6 100 ha has been identified as a priority area. It is probable that a 60 ha trial area will be implemented in 1980.
Dujuma settlement	15 000	Rice, maize, pulses, sesame	See notes	Unlikely to be developed since soils only marginally suitable. Fanoole-Homboy is alternative development area.
Fanoole-Gelib (state farm)	8 200	Rice, maize, cowpeas, cotton, sesame, groundnuts	Implementation 2 500 ha cleared, 1 200 ha cropped	Present cropping limited by temporary pumped water supply. Supply will eventually be from Fanoole barrage which is currently under construction.
Fanoole-Homboy (settlement)	9 000	Maize, pulses, sesame, cotton, rice	Design phase	Designs due to be completed by January 1980.
Juba Sugar	13 000 max	Sugar	Construction phase	Seed cane is already being grown and it is planned to have 2 000 ha of cane planted by the end of 1979.
Trans-Juba feedlot	1 200	Fodder crops	Construction phase	Plans at present to develop only 300 ha of irrigated fodder.
Mogambo	6 400	Rice, maize, cotton	Feasibility study	This report
Jamama cotton	2 000	Cotton	Construction	Plans at present to develop only 300 ha under the control of Somaltex.
Banana plantations	5 000	Bananas	Established	Recent years have seen a decline in banana production but there are plans to expand in the future. Expansion cannot take place without the guarantee of perennial water supplies.
Ionte rice farm	200	Rice	See notes	Currently growing 40 ha coconuts.
Torda scheme	2 400	Cotton	Post feasibility	There are no plans to implement this scheme at present.

3.3 Sociological Aspects

The population of Jamama district according to the District Commissioner is 84 000, of whom some 12 000 live in the Jamama township. This figure appears to be only slightly in excess of the population figures for 1975, which gave the total for the whole region as 223 000 of which 70% were said to be nomads. The nomad population of Jamama district is believed to be no more than 40%, so the settled agriculture-orientated population is likely to be around 50 000.

The main occupation of the settled population is subsistence agriculture supplemented by labour on banana estates or in trading or service industries. There is also considerable livestock activity by the nomads, who occupy temporary villages at certain seasons of the year. The relationship between the nomads and the agriculturalists is one of interdependence, with the agriculturalists herding their livestock with the nomads' cattle and the nomads obtaining food supplies in return. Many of the agriculturalists belong to a different ethnic group from the nomads, related to the Swahili speakers to the south. They constitute the bulk of the settled population.

The majority of the villages are strung out along both banks of the Juba river. As a consequence of this and of the use of irrigation associated with many of the villages, the incidence of irrigation diseases is high. This is particularly the case with bilharzia, for which disease an incidence as high as 80% is reported by the regional medical authorities. Primary education is very much favoured in the region as a whole, and the ratio of schools to pupils is well above the national average.

3.4 Agriculture

It is estimated that there are between 1 500 and 2 000 farm holdings in the Mogambo study area. These holdings are not large, varying in size from 0.5 to 5.0 ha, and the majority of holdings are of around 1 ha. Holdings are rarely held in compact blocks and frequently farmers 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.

Maize is the main crop grown in the gu season. Planting takes place in April and May and harvesting follows 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, but can also be planted in residual moisture following flooding. Beans are frequently interplanted with these crops in both seasons. Supplementary crops include yams, tomatoes, cassava, paw paws, tobacco and sugar cane.

Primary cultivation is rarely practised and land preparation is usually confined to small basins prepared by hand with a yambo. Some areas however are prepared mechanically by tractor using ploughs or disc harrows but the availability of this service, which is provided by ONAT, is restricted. Some farmers can afford to hire tractors from the banana plantations.

Local varieties of crops are grown, often from seed of poor quality, and no fertilisers are used. Harvesting is by hand and although this can be reasonably efficient some losses through shattering of sesame occur. 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.

Yields vary from year to year and place to place and, although no reliable statistical data are available, they are generally accepted as being in the order of 300 kg/ha for sorghum, 400 kg/ha for maize and 200 kg/ha for sesame.

The crops which are grown by the local farmers are either consumed by them or are sold to ADC.

There is a large number of banana plantations between the project area and the river which are irrigated by water pumped from the river. These are owned either privately or by the National Banana Board (ENB) and many of the local people are employed as labourers on the plantations. The marketing of the bananas is organised by ENB. It is clear that the area under bananas has declined recently since large tracts of land which have in the past been cultivated are now lying fallow. Often these areas are those furthest from the river (nearest to the project area).

3.5 Livestock

The most important factor determining the extent of animal husbandry in the study area is the presence of the disease trypanosomiasis. The riverine woodland and thick **Acacia/Commiphora** bush found throughout much of the Mogambo project area is the ideal habitat for the tsetse fly which is the vector for the disease. Because of this, only limited use is made of the area by livestock and most stock owners manage their animals on the principle of avoiding infection rather than using prophylactic cover from drugs.

Cattle, sheep, goats, donkeys and camels are all found in the project area, though the first three are by far the most important classes of stock. Poultry are also found in most villages.

The constant threat from trypanosomiasis means that, unlike most rural areas in Somalia, livestock production takes second place to crop production in the area. Livestock are found in all the villages but meat and milk are not as important to the people as agricultural produce.

In the areas away from the river, and outside the Mogambo project area, the situation is very different and livestock are the most important source of subsistence and cash income. Southern Somalia is the most important cattle area in the whole country, but the majority of production takes place away from tsetse infected locations.

Although cattle are used primarily as a source of milk, and small stock (sheep and goats) as a source of meat, cattle also make a significant contribution to draft power. In most of the villages in the project area there is at least one draft ox working a simple cart. These oxen are invariably in very good condition and are well looked after by their owners.

Animals are hand fed at certain times of the year, being fed freshly cut grass, maize stover or sesame cake. The sesame cake comes from the small oil mills found in the villages. It appears, however, that the bulk of sesame cake is sent to Kismayo rather than used in the villages.

The productivity of poultry is low. The birds are mostly of unimproved stock and have to scavenge in the villages to obtain their food.

The present situation regarding livestock in the Mogambo project area is therefore not typical of the majority of Somalia. It is unlikely that the development of the Mogambo irrigation project will have any great detrimental effect in the present livestock production systems of the immediate area. Indeed, clearing of land will reduce the tsetse problem and there will be a greater variety and amount of crop residues.

3.6 Institutions

The nature and function of a country's institutions are determined largely by its political philosophy. In the case of Somalia, the events of 1969 led to the adoption of a policy of scientific socialism whereby the economy of the country became a matter for state control and the means of production were seen as belonging to the producers, but under the management of the state. This has led to the creation of some fifty state owned or managed corporations or authorities.

The control of the affairs of the country is institutionalised through the normal system of ministries which in general are concerned most directly with the evolution of policy within the particular sector of the economy or of the social framework which comes within their terms of reference. In addition to their concern with the development of policy, these ministries are responsible for the administration and supervision which delimits the activities within their sectors. Each ministry usually has a planning unit within its structure, or an individual with a planning brief, so that it can pursue its activities in a proper perspective in relation to its funds, priorities and responsibilities. The State Planning Commission, which is an institution responsible directly to the President, is required to take an overview of the country as a whole and to identify priorities by sectors in relation to resources available.

The actual operations within the different sectors are often entrusted to the state owned, semi-autonomous institutions previously referred to, which are under the control ultimately of the minister concerned. Most of the 21 ministries in the Government have at least one such agency, some have two or three, and the Ministry of Industry has as many as thirteen. The performance of these agencies is uneven because of the overall shortage of the most essential of all resources, that of trained and experienced manpower.

Of the 21 ministries, there are seven which are to a greater or lesser degree involved in developments such as the Mogambo project. The one most deeply involved will be the Ministry of Agriculture, with its three important authorities. These are the Agricultural Development Corporation (ADC) with responsibility for the marketing of the major crops, ONAT with responsibility for the distribution of mechanical equipment and agricultural inputs and the National Banana Board (ENB) with responsibility for the production and marketing of bananas.

The regional organisation of the Ministry of Agriculture is run by a regional co-ordinator, with the district officers from those functional directorates of the ministry concerned with specific agricultural operations in the district, wherever manpower shortages permit.

The Ministry of Industry will not be directly involved except through two of its agencies. One of these is Somaltex which controls the ginning and textiles industries of the country, and the second is the Mogadishu Oil Mill where all the vegetable oil milling capacity of the country is at present concentrated. The other important agency is the Kismayo Meat Factory.

The other ministries concerned are the Ministry of Livestock, Forestry and Range (MLFR), the Ministry of Commerce through its Agency for Vehicles and Spare Parts (WAGAD), the Ministry of Education (MOE), the Ministry of Health (MOH) and the Ministry of Labour (MOL).

The MOE is organised very much along the lines of the MOA, with a director general and functional directorates at Mogadishu, and regional and district inspectorates up country. The MOH organisation is based upon a hierarchy of hospitals at regional level, health centres at district level and dispensaries and first aid posts in the villages. The MOL is concerned rather with the enforcement of the complex labour legislation, but also has a valuable contribution to make in locating and advising on the possible sources of seasonal labour.

3.7 Infrastructure

The general planning infrastructure has been mentioned briefly above. The particular problems of the Juba valley call for a particular planning agency which does not at present exist. There is already a number of projects in the valley at the implementation stage. In the immediate vicinity of Mogambo, for instance, there are the Juba Sugar project, the Fanoole-Gelib state farm and the Trans-Juba livestock project. There is also extensive banana cultivation, in small and medium sized estates, which represents the second most important of the country's exports. These estates depend upon the waters of the Juba, just as the other projects do, and just as Mogambo and a number of other projects already approaching the planning stage will. The need for an authority to collect data, to allocate water and to discuss with Government the priorities for crop and livestock production is obvious, and it is recommended that early action is taken to establish a Juba Valley Development Authority, with the necessary powers. Its authority would need to extend to the proposed Bardheere dam to the extent that it would be able to base its policy either on a situation with the dam or equally certainly on a situation without the dam.

In other respects, the institutional infrastructure of the Lower Juba region is on the whole provided at a rate above the average pertaining in most other regions. There are more hospitals and dispensaries, doctors and medical assistants per 1 000 head of population than is generally the case elsewhere, with the exception of the Benadir region (Mogadishu). The same applies to the number of primary school classrooms, teachers, domestic schools and community centres. Furthermore, what applies to the region as a whole applies particularly to Jamama district within which the Mogambo project area is scheduled. It must be emphasised, however, that the provision of services is very low, and that there is ample justification for offering a level of services within the Mogambo project above that which exists already.

Road communications within the district are good, there being a good quality surfaced road from Kismayo to Gelib with a branch road of similar quality to Jamama. The project area is adjacent to this road. The road to Mogadishu is at present unsurfaced along much of its length and is therefore impassable after heavy rains. However, a new road is currently under construction and this will be completed in the near future.

Telephone communications in the district are not good although it is possible to telephone Mogadishu from Gelib, Jamama and Kismayo through a radio-telephone link.

There is no electricity supply network in the district.

3.8 Economic Considerations

Somalia's per capita gross domestic product for 1977 was estimated by IBRD to be US $110. The results of the 1975 census showed a population of 3.5 million dispersed over an area of 637 000 km^2. Of this population, nationally 60% were nomadic; the nomadic percentage was only 40 in the Shabelle valley but rose to 70% in the Juba valley. Life expectancy is only 41 years, and 70% of rural and nomadic families have a food intake below the level required to establish a minimum diet of 2 200 calories per day per adult person.

The majority of the population is engaged in agriculture or livestock-raising, and these activities account for some 85% of the value of exports. The trade in live animals shipped to the Gulf and the export of bananas are the most important. However, in 1977 the value of exports came to only 35% of that of imports. The balance of payments situation is redeemed by considerable inflows of foreign grants and aid, and substantial amounts of money or goods in kind are repatriated by Somalis working overseas, particularly in Saudi Arabia. However, the value of food imports in 1977 was two-thirds of the value of all exports.

Government strategy has been based on a series of national development plans, the latest of which ran from 1974 to 1978. Only half the plan was implemented, but the period in question was a difficult one for Somalia with world-wide inflation pressures, a drain of skilled labour to the newly oil-rich nations, the effects of a very severe drought, and a diversion of resources to border conflicts. A new Three Year Development Plan is now being implemented, under which agriculture, livestock and fisheries should account for 36% of the expenditure. Increased food production and better living standards are major national goals.

3.9 Marketing

3.9.1 Institutions

Four government bodies are concerned in the marketing of project produce. The Agricultural Development Corporation (ADC) purchases food crops from farmers and distributes them. ADC also supplies seed, provides storage and transport, operates rice and maize processing plant and imports some cereals i.e. maize, sorghum and wheat. Farmers are required to sell to ADC, except that 2 quintals of each crop may be retained per family member.

The National Trading Agency (ENC) was originally established to receive aid donations, but now acts as a commercial purchasing agency. The major commodities imported include pasta, wheat flour, rice, tea, sugar, coffee, edible oils and dates, and these commodities are distributed to the regional level by ENC.

The National Banana Board (ENB) plays a key role in banana production in Somalia. ENB supplies inputs to farmers and technical advice, operates research and demonstration farms, arranges for packing, transport, storage and handling of the fruit and exports under the 'Somalia' trademark, principally to Italy and Kuwait.

Somaltex operates a cotton gin and textile facory at Balad, and purchases the great majority of seed cotton produced in Somalia. Another gin is owned at Jamama, and Somaltex is increasingly offering technical assistance and encouragement to farmers.

3.9.2 Commodities

The national production of rice, at 4 000 tonnes per year, lies far behind imports of over 30 000 tonnes, and projections show that demand is due to rise even further. Various production schemes have been proposed, but a substantial shortfall is expected for the next ten years. To encourage production, ADC offers relatively high prices, of SoSh 350/quintal of long-grain rice and SoSh 285/quintal of short-grained. World price forecasts indicate a rise of over 30% in real terms by 1985.

In contrast, some 250 000 tonnes of sorghum and maize are estimated to be produced in Somalia, although only 25% is traded via ADC. Annual imports vary between 20 and 30 000 tonnes, still reflecting a drain of foreign exchange. Demand is expected to rise although less than for rice, but prospects for expanding production are limited. Farmgate prices offered by ADC for both maize and sorghum are SoSh 75/quintal, but a 30% world price rise in real terms is forecast for 1985.

Sesame is the most important of the locally grown oilseed crops, but national production of edible oils in 1978 totalled some 9 000 tonnes, compared with 14 000 tonnes imported. Demand for edible oils is expected to rise in the future, but plans for increasing national production are limited. ADC presently pays SoSh 240/quintal of sesame at the farmgate, and a 10% world price rise is forecast for 1985.

Domestic production of cotton lint in 1978 totalled 430 tonnes, compared with imports of 1 700 tonnes. The capacity of the textile factory is well in excess of present domestic production, and demand for textile products is expected to increase. Various schemes proposed include cotton components but a continued shortfall is expected. The present ginnery gate price for grade A cotton is SoSh 260/quintal; only a moderate rise in world prices is forecast.

Banana exports have fallen from 133 000 tonnes in 1972 to 57 000 in 1978 owing to a combination of production and marketing difficulties. The traditional strength of the Italian market has been eroded but new opportunities are being developed in Arabia. New technical assistance programmes are to be implemented in order to increase production, and future export prospects are good. Of the FOB Somali port price of SoSh 124/quintal, the producer receives SoSh 56.50 after deductions for packing stations, cartons, transport and handling charges. Only a 9% world price rise is forecast. Some 20% of all bananas produced are sold on the local market, at a varying price averaging SoSh 20/quintal.

Hydrology

4

CHAPTER 4

HYDROLOGY

4.1 Introduction

Three rivers rising in the Ethiopian highlands meet near Dolo to form the Juba river, which flows in a south-easterly direction to enter the Indian Ocean at Kismayo. The total catchment area is about 330 000 km^2, with annual average rainfalls varying from about 200 to 1 600 mm. About 83% of this rainfall falls in the headwaters above Dolo (MMP 1978).

River flows vary considerably within a year, generally rising rapidly in mid-April to flows of 100 m^3/s or more in a matter of days. These flows are maintained or exceeded until early January, when they fall to 20 m^3/s or less, until mid-April. Zero or negligible flow conditions have been reported in the Lower Juba on at least three occasions during the last 40 years.

Flooding in the Juba basin occurs in most years, usually during October and November in the der season when considerable volumes of water pass down the river often with one flood superimposed on another. River banks are overtopped in many places resulting in extensive flooding and attenuation of flood peaks. Flood peaks of more than 1 000 m^3/s have been recorded at Lugh Ganana, near the head of the Juba basin.

In addition to studies of low flows and flooding, the hydrological studies presented in this report have also included calculation of irrigation water requirements for Mogambo and other projects, and an assessment of drainage rates from cropped areas for use in design work. All these studies are reported in detail in Annex 1 and are summarised in the following sections, together with a short discussion on groundwater.

4.2 Flood Hazards

High river flows in the River Juba can occur in May, during the gu season, but these are normally comparatively small. The highest flows and worst floods usually occur in October or November during the der season. River banks are overtopped in many places between Bardheere and Kamsuma, causing considerable flooding on both sides of the river. The resulting flood plain storage results in appreciable attenuation of peak flows.

Only the Lugh Ganana gauging station, some 400 km to the north of Mogambo, has a sufficiently long record to calculate peak flows occurring with given return periods. Most work was therefore concerned with obtaining the peak flow/return period relationship for Lugh Ganana and transposing it to Kaitoi and Kamsuma by means of relationships between flows at the three stations. The resulting flows at Kamsuma were then expressed as water levels at Bulo Yaag, the proposed intake site, utilising the results of backwater curve calculations. Table 4.1 shows these flood levels.

TABLE 4.1

Return Periods of Bulo Yaag Water Levels under Present Conditions

Return period (years)	Peak flow at Kamsuma (m^3/s)	Water level at Bulo Yaag (m AMSL)
2	600	12.3
10	710	12.5
25	750	12.9
50	780	13.0
100	800	13.1

Note: Calculated water levels suggest that overtopping of Bulo Yaag flood gates, at a level of 12.5 m AMSL, occurs in most years. However, it is reported that these gates are overtopped infrequently and the levels in the above table therefore include a reduction of 0.4 m to give better estimates for stated return periods.

Water levels in Table 4.1 apply only if upstream conditions remain unchanged. However, flood protection works are under construction for the Juba Sugar project and are planned for the Fanoole project, involving bunding of a large proportion of both banks of the river between Kaitoi and Kamsuma. Peak flows at Kamsuma will increase substantially when these bunds are complete. For example, the 10 year return period flood at Kamsuma will increase from 710 to 900 m^3/s and water levels at Bulo Yaag will increase from 12.5 to 14.0 m AMSL.

It is understood the Bardheere dam could be complete within the next eight years although no definite decision has yet been made. Previous work (Technital, 1977 and HTS, 1978) has shown that, with Bardheere dam, the annual risk of flood peaks exceeding 750 m^3/s can be reduced to 1%. The corresponding flood peak at Kamsuma will be only about 700 m^3/s, allowing for attenuation effects remaining after construction of bunds on the Juba Sugar and Fanoole projects. Bardheere dam will therefore reduce the risk of flooding at Mogambo to a very low level and extensive bunding of the Mogambo project will not be required if the project is delayed until Bardheere dam is operational.

4.3 Irrigation Water Requirements

Several changes in planned irrigation developments have been made since the Fanoole Settlement Report (HTS, 1978) which considered future water requirements throughout the Juba basin. These changes have required re-calculation of water requirements and the opportunity has been taken to include planning horizons of 1985 and 1990 (short and medium term) in addition to an evaluation of the situation in 1980 (immediate term).

This method of Doorenbos and Pruitt (1977) was used to calculate monthly values of reference crop evapotranspiration for the Bardheere-Gelib, Gelib and Ionte-Gelib climatic zones. Effective rainfall was calculated by applying the criteria of the US Bureau of Reclamation, as reported by Lockwood/FAO (1968), to monthly rainfall occurring with an 80% probability of exceedence.

4.1

Juba river gauging stations

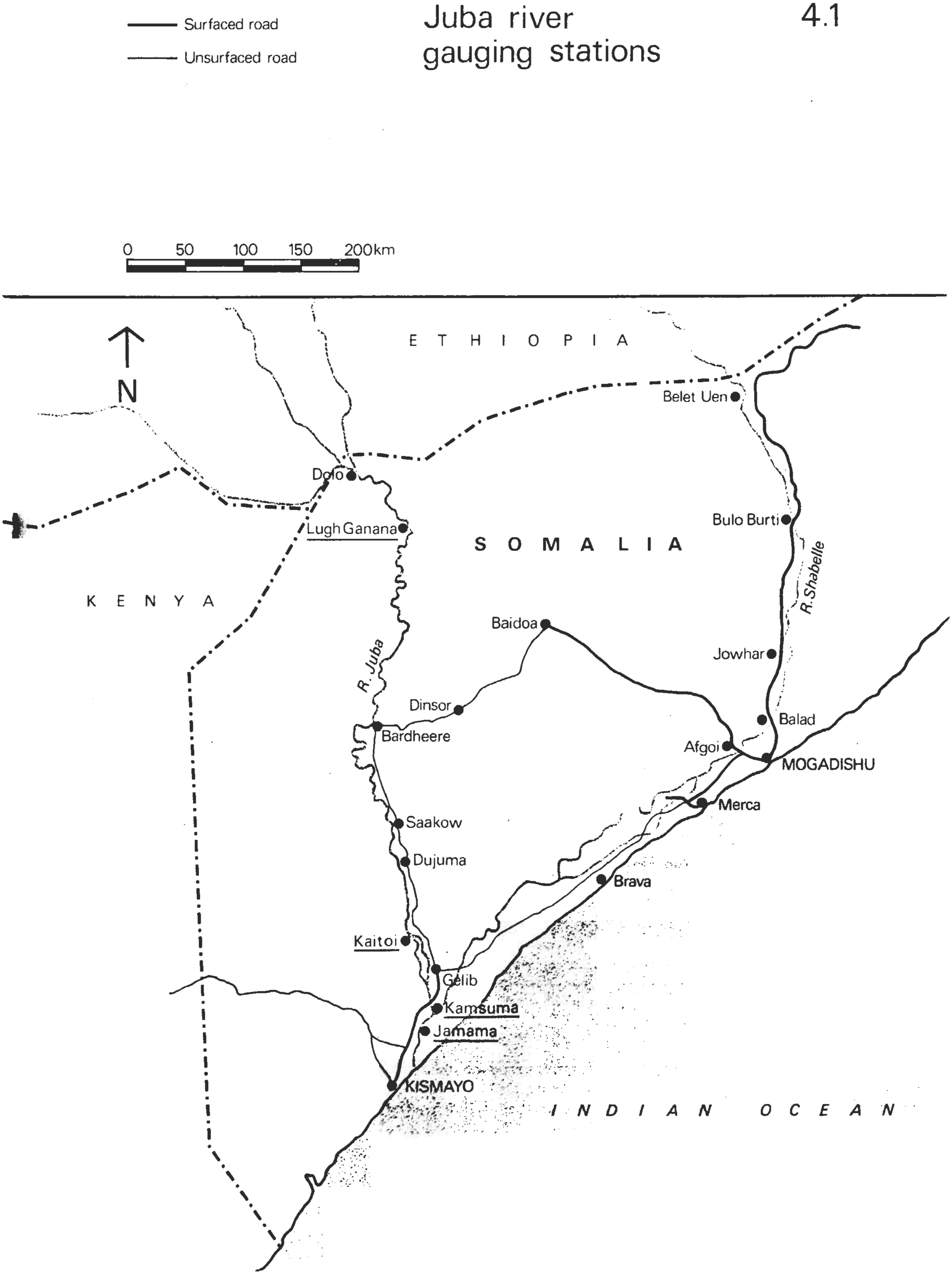


TABLE 4.2

Incremental Water Use on Juba River to 1990 (Mm^3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(a) by 1980												
Above Kaitoi	0.4	0.1	0	0	0.3	0.7	0.6	0.2	0	0.2	0.5	0.6
Kaitoi-Kamsuma	16.8	13.9	16.1	9.6	11.0	13.3	13.3	13.0	14.2	16.2	14.9	6.6
Kamsuma-Mogambo	0	0	0	0	0	0	0	0	0	0	0	0
Below Mogambo	0.6	0.6	0.6	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.4	0.5
Total	17.8	14.6	16.7	9.9	11.6	14.4	14.3	13.6	14.7	16.9	15.8	7.7
(b) by 1985												
Above Kaitoi	0.9	0.3	0.1	0	9.6	19.1	16.9	10.0	17.5	26.5	24.5	12.9
Kaitoi-Kamsuma	86.0	66.3	78.5	44.5	55.7	71.2	66.0	61.7	78.6	100.1	90.8	85.3
Kamsuma-Mogambo	1.1	1.1	1.2	0.5	0.5	0.6	0.6	0.8	0.9	0.9	0.7	0.9
Mogambo	2.6	0	0	8.2	17.5	12.0	10.5	4.1	8.8	9.5	12.2	12.6
Below Mogambo	31.5	25.0	27.4	26.2	27.2	26.3	27.2	28.1	32.1	35.5	33.1	34.6
Total	122.1	92.7	107.3	79.4	110.5	129.4	121.2	104.7	137.9	172.5	161.3	146.3
(c) by 1990												
Above Kaitoi	0.9	0.3	0.1	0	9.6	19.1	16.9	10.0	17.5	26.5	24.5	12.9
Kaitoi-Kamsuma	106.3	80.7	96.1	55.4	70.6	91.7	84.1	76.2	99.7	129.9	117.7	110.6
Kamsuma-Mogambo	2.3	2.2	2.5	1.0	1.0	1.2	1.3	1.6	1.9	1.9	1.4	1.8
Mogambo	2.6	0	0	8.2	17.5	12.0	10.5	4.1	8.8	9.5	12.2	12.6
Below Mogambo	31.5	25.0	27.4	26.2	27.1	26.3	27.3	28.1	32.1	35.5	33.1	34.6
Total	143.6	108.2	126.1	90.8	125.8	150.3	140.1	120.0	160.0	203.3	188.9	172.5

Crop calendars and crop coefficients were generally taken from the Fanoole report (HTS 1978) except those for the Mogambo project where crop coefficients were calculated specifically for the project (Annex 3).

Gross irrigation requirements include an overall efficiency of 45% (60% field and 75% distribution efficiency) except for the Juba Sugar project where sprinklers increase overall efficiency to 52% and the Mogambo area where specific assumptions are made for the two soil types. The incremental water uses (increases over present use) given in Table 4.2 assume that present use is only 80% of the projected 1980 requirements of small schemes above and below Fanoole. This is a reasonable assumption, given that available river flow data primarily apply to the period before planned development of the River Juba was initiated. Incremental water uses also include allowances for Kismayo water supply and residual flow requirements.

4.4 River Flow Availabilty

The Kamsuma gauging station is situated about 16 km upstream of Bulo Yaag, the proposed intake point for the project, and hence is the most convenient station for estimating river flow availability. In order to provide the maximum possible information on the river flow at Kamsuma, all available data sources have been employed, making full use of previous studies.

Past studies have made use of correlations between flows at Lugh Ganana, the principal gauging stations on the River Juba, and short period records at stations on the coastal plain. However, the use of records from this station suffers from the long reach of river between Lugh Ganana and the sea, making it particularly difficult to estimate low flows in the period January to March/April.

In this report, published monthly flows at Lugh Ganana, from Selchozpromexport (1973), have been correlated with those at Kaitoi, employing separate regression equations for both the high and low flow regimes. These flows were then related to Kamsuma, producing a composite record spanning the periods 1951 to 1965 and 1972 to 1975.

A similar exercise was carried out to extend the records at Kamsuma by correlation with published monthly flow data at Jamama (Lockwood/FAO, 1965) some 52 km downstream.

As an alternative approach to using regression techniques, recorded low flows at Lugh Ganana were reduced by a fixed quantity to allow for losses due to direct abstractions and evapotranspiration. This approach has an additional advantage in that the station is above the area of direct irrigation abstractions and so no allowance has to be made to adjust records to account for variations in abstractions over the period of record. Due to the unexplained difference between low flows at Lugh Ganana quoted by Selchozpromexport in 1965, and their subsequent report in 1973, both sets of data have been reduced to provide estimates of flow at Kamsuma.

No logical choice can be made between the sets of water availabilities at Kamsuma obtained using the various forms of analysis, hence the four estimates have been combined and average values determined. Table 4.3 shows return periods and present water availability at Kamsuma and Table 4.4 shows future water availabilities at Kamsuma based on a 5 year return period.

The use of monthly flows to calculate water availability is suitable for most months in the year, the exception being April when the river starts to rise following the gu season rains. Hence, since the planned crop calendar for the Mogambo project requires that rice planting starts as early as possible, a separate analysis was carried out on the timing of the gu flood and the localised April rains. By treating the localised rains and the start of the gu season river flood as independent events, it was shown that the most optimistic projection is that there will be enough water in four out of five years, from either river flow or rainfall, to carry out initial planting by the second week of April.

TABLE 4.3

Present Water Availabilities at Kamsuma (Mm^3)

Month	Return period (years)			
	2	4	5	10
January	92	51	47	38
February	33	19	19	10
March	27	10	8	4
April	157	71	64	48
May	556	342	278	135
June	400	220	193	97
July	442	305	276	186
August	678	530	477	441
September	704	602	516	418
October	1 228	751	656	537
November	838	636	563	465
December	333	207	181	152

Bardheere dam could be in operation within eight years although it is understood that no firm decision has yet been made. The reservoir would have a gross capacity of 4 100 Mm^3 (Technital, 1977) and would fulfill flood control, hydro-power and river regulation functions. Previous studies (MMP, 1978) have shown that the proposed storage capacity is sufficient to fulfill these functions for the foreseeable future, in particular meeting future downstream irrigation demands with a very high reliability during the four driest months, January to April, even with high rates of water use upstream.

4.5 Drainage Rates from Cropped Areas

Flood irrigation of rice followed by surface irrigation of maize in bunded fields is proposed for areas with heavy basin soils. Areas of lighter levee soils will remain unlevelled and used to grow cotton and other crops irrigated by sprinklers. Drainage characteristics of the two areas will be different and have been treated separately.

TABLE 4.4

Future Water Availabilities and Requirements at Mogambo (Mm^3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(a) by 1980												
Water availability	30	5	0	54	267	179	262	464	502	640	549	173
Requirements	0	0	0	0	0	0	0	0	0	0	0	0
Surplus/deficit	30	5	0	54	267	179	262	464	502	640	549	173
(b) by 1985												
Water availability	0	0	0	18	211	102	192	404	418	528	466	83
Requirements	3	0	0	8	18	12	11	4	9	10	12	13
Surplus/deficit	-3	0	0	10	193	90	181	400	409	518	454	70
(c) by 1990												
Water availability	0	0	0	8	196	81	174	389	396	497	419	55
Requirements	3	0	0	8	18	12	11	4	9	10	12	13
Surplus/deficit	-3	0	0	0	178	69	163	385	387	487	407	42

The following phases have been identified for bunded basin soils:-

(a) April and May, when young rice seedlings must be protected against drowning

(b) May to August, when taller rice is irrigated to a depth of 150 mm, following a 9-day irrigation cycle

(c) September to January, when maize is grown.

Each phase has been considered separately, using a daily water balance based on daily rainfall records for Alessandra (Gelib) covering the periods 1930 to 1939 and 1953 and 1960. In the two rice cases, full account has been taken of field storage. Inter-field bunds are at least 200 mm high, compared with normal water depths of 150 mm for mature rice immediately following irrigation; thus field storages in this case are 50 mm. Parts of the area will have been irrigated up to 8 days previously and water levels will have fallen by up to 70 mm due to infiltration and evaporation losses, giving field storages of 130 mm. Similarly, it can be shown that field storages for young rice seedlings will range from zero, in the case of newly seeded rice, up to a maximum of 100 mm in the case of rice sown one month previously.

In the case of the maize crop in bunded fields, reduced yield and/or loss of crops will occur if flooding is deep or prolonged. Field storage of excess rainfall would normally not be allowed and will only occur if rainfall is greater than maximum drainage rates. Flood depths and durations were assessed by daily water balance for drainage rates of 1, 1.5 and 2 l/s/ha, assuming daily water losses of 10 mm and 5 mm due to infiltration and evaporation respectively.

Drainage rates required for young rice were found to be greater than those required for tall rice. Table 4.5 shows maximum drainage rates for young rice and their corresponding return periods. Using a drainage rate of 1.5 l/s/ha for the maize crop, it was found that the maximum duration of flooding was 3 days, occurring on only 2 occasions during the rainfall record of 18 years. The maximum depth of flooding was 70 mm. A design drainage rate of 1.5 l/s/ha would thus be adequate to protect crops against flooding at least 4 years in 5.

TABLE 4.5

Maximum Annual Drainage Rates for Young Rice

Return period (years)	Drainage rate (l/s/ha)
2	0.8
4	1.3
5	1.5

For levee soils, irrigated by sprinklers, the USSCS (1964) method was used to estimate maximum annual drainage rates. The method is based on an initial abstraction, which is dependent on antecedent rainfall and which represents the loss of rainfall due to infiltration and retention of storm rainfall.

Calculations of drainage rates from basins and levee soils assume that point rainfall measured at Alessandra falls uniformly over the whole area. During fieldwork for this study, it was observed that rainfall is very localised, parts of the area remaining dry whilst other parts received rain. The calculated drainage rates are therefore overestimates when considering the whole area although they will apply to small areas drained by a collector drain. Reduction factors of 0.9 were thus applied to main collector drains and a further 0.9 to main drains. Table 4.6 shows the resulting maximum drainage rates and return periods for basin and levee soils.

TABLE 4.6

Drainage Rates (l/s/ha) and Return Periods

	Return periods (years)		
	2	4	5
(a) Basin Soils			
Collector drains	0.8	1.3	1.5
Main collector drains	0.7	1.2	1.4
Main drains	0.6	1.1	1.2
(b) Levee Soils			
Collector drains	1.6	2.9	3.5
Main collector drains	1.4	2.6	3.2
Main drains	1.3	2.3	2.8

The values for the 5-year return period have been used in the design of the drainage system.

4.6 Groundwater Resources

The Lower Juba plain is formed of alluvial deposits, up to several hundred metres deep, overlying Jurassic limestones in the north and Tertiary marine sediments in the south. The terrain is flat, with a small gradient from north to south.

Only eleven logged boreholes are recorded in the 70 000 km^2 area (Johnson/FAO, 1978). Very shallow wells yield water with total dissolved solids (TDS) of between 1 000 and 4 000 parts per million (ppm), increasing to 10 000 ppm or more with depth. Work on the same hydrogeological complex in Kenya has failed to produce any worthwhile water and it is probable that similar results would be found in Somalia (Johnson, ibid).

The nearest known well to the Mogambo area was drilled for the Trans-Juba livestock development project. Details are summarised in Table 4.7. The quoted conductivity is equivalent to total dissolved solids of about 1 200 ppm. Water of this nature is of doubtful quality for irrigation. A second well drilled 300 m west gives water with a conductivity of 1 550 micromhos/cm (about 950 ppm) but no other details are available.

On available evidence, it appears unlikely that sufficient good quality water can be obtained for irrigation. However, water for human and livestock consumption is probably available. The WHO (1971) recommends a maximum TDS of 1 500 ppm for drinking water and on this basis both the Trans-Juba boreholes yield water of acceptable quality.

TABLE 4.7

Details of Borehole Drilled for Trans-Juba Livestock Development Project

Location:	Mashago
Depth:	105 m (backfilled to 80 m)
Diameter:	300 mm, 0 to 75 m deep 250 mm, 75 to 105 m deep
Casing:	200 mm dia.
Screen:	200 mm dia., wirewound, 51 to 60 m deep
Yield:	24 m^3/h
Static water level:	7 m below ground
Conductivity:	2 000 micromhos/cm (during pump test)
Geology (m depth)	
0 - 6	Clay, loamy
6 - 12	Loam, with very fine sand
12 - 18	Gravel, medium to fine and sand, medium gravel with marl interbedded
18 - 49	Sand, fine to medium, with fragments of crystalline rock, interbedded calcareous gravel, trace of limestone
49 - 70	Gravel, calcareous, rounded with fine to medium sand
70 - 89	Clay, with roughly rounded gravel and fine sand
89 - 105	Clay, grey to light grey with trace of calcareous gravel

Source: Trans-Juba livestock project

PART II

THE PROJECT

Project Description 5

CHAPTER 5

PROJECT DESCRIPTION

5.1 Introduction

The Juba river valley has long been recognised as an important agricultural development area and a number of possible projects have been identified and studied. The Selchozpromexport report of 1965 (The Juba River Scheme) suggested several possible development areas including the 'Bardera-Ionte' area which encompassed the area covered by the Mogambo irrigation project study. The Selchozpromexport proposals included a barrage on the river at Qaliakoko, approximately 35 km north of Jamama, with a canal running along the edge of the marine plain and feeding the lands between it and the river.

The Qaliakoko barrage concept has not been considered beyond prefeasibility stage, and the subsequent TAMS/FINTECS (1977) study proposed a pumped supply for the Mogambo project. Clearly the implementation of the Mogambo area alone could not justify the construction of a river diversion structure. A pumped supply is therefore proposed for the Mogambo project. A total net irrigable area of 6 400 ha has been identified.

5.2 Planning Considerations

The general development of the policy of the Government lays stress upon a number of objectives, four of which are particularly relevant to the Mogambo project. They are :-

(a) the need for self-sufficiency

(b) the conservation of resources

(c) the improvement of the standard of living

(d) the provision of productive employment in rural areas.

The project area is at present relatively unproductive, so the irrigated agriculture proposed has to be seen as optimising the use of land and water in fulfilment of the first of these general objectives, so long as the cropping pattern is consistent with the capability of the soils and the economical use of the water. An additional factor affecting the choice of cropping pattern is the question of when Bardheere dam is to be built but, since the dam project has not yet been officially sanctioned, the proposals for Mogambo must be flexible enough to meet a situation under which the dam would not be built.

Resource conservation can readily be achieved within the limited extent of the framework of the Mogambo project, but a much more significant impact in this respect would be made if a Juba Valley Development Authority were to be established. It is very much in the interests of planning for Mogambo to advocate immediate action on the wider planning needs.

The other two planning objectives introduce two particular problems of choice. The first choice is over the form of the project, which is discussed in Chapter 6.

The second choice is between a labour intensive and a machine intensive agricultural system. The advantages of a labour intensive agricultural system are very clear in respect of the productive employment of as many people as possible in the rural areas. The problem is to determine whether labour in the quantities needed for the crops chosen could be assembled, with sufficient assurance that operations such as the hand picking of cotton could be accomplished. There is evidence to suggest that despite obvious underemployment in the project area and the surrounding district, the availability of labour in large quantities cannot be guaranteed.

The advantages of a mechanised system of crop production, from primary cultivation to harvest, are equally clear. Indeed, in order to ensure the crop yields required to justify the capital investment for the Mogambo project, mechanisation of many of the operations is essential. Consider, for example, the rice crop which is proposed for the basin soils covering 3 300 ha net (Chapter 7 herein). In order to ensure that this crop is planted and harvested in time to permit a subsequent maize crop to be grown, the operations must be carried out quickly and efficiently. Without a large available workforce experienced in rice cultivation the only alternative in the context of a state farm is a mechanised system.

Mechanisation has also been considered for the cotton crop harvest but, in view of the fact that the system proposed is relatively untried and there is no experience of it in Somalia, this was rejected in favour of a hand picking system. The area of the cotton crop has been limited to 1 100 ha total since the availability of labour required to pick a larger area cannot be assured. Of this, 100 ha will be used as a trial area for a mechanised system in order to test the viability of such a system in Somalia.

The success of a mechanised farm will depend to a large extent on three factors. These are:

(i) a well organised and efficient management structure

(ii) a well maintained fleet of machines and vehicles with a good supply of spare parts

(iii) a workforce of skilled operators

The project has therefore been conceived with these factors in mind and the proposals are discussed briefly in the following chapters in this volume and, in more detail, in Annexes 3 and 6.

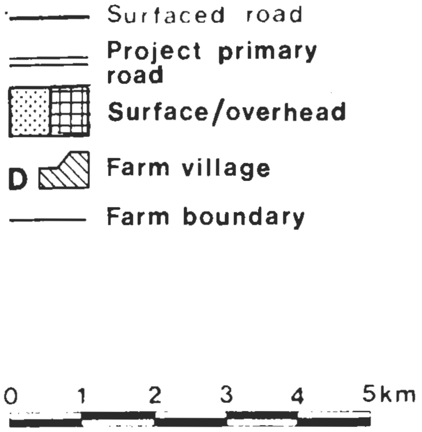
Although the aim has been to adopt mechanised processes where possible, there are still many operations which will have to be performed manually, such as cotton harvesting, and consequently the project will require a substantial labour force. In order to guarantee the availability of this workforce, consideration has been given to ways of encouraging workers to take up residence in the project area and this is discussed in detail in Annex 6.

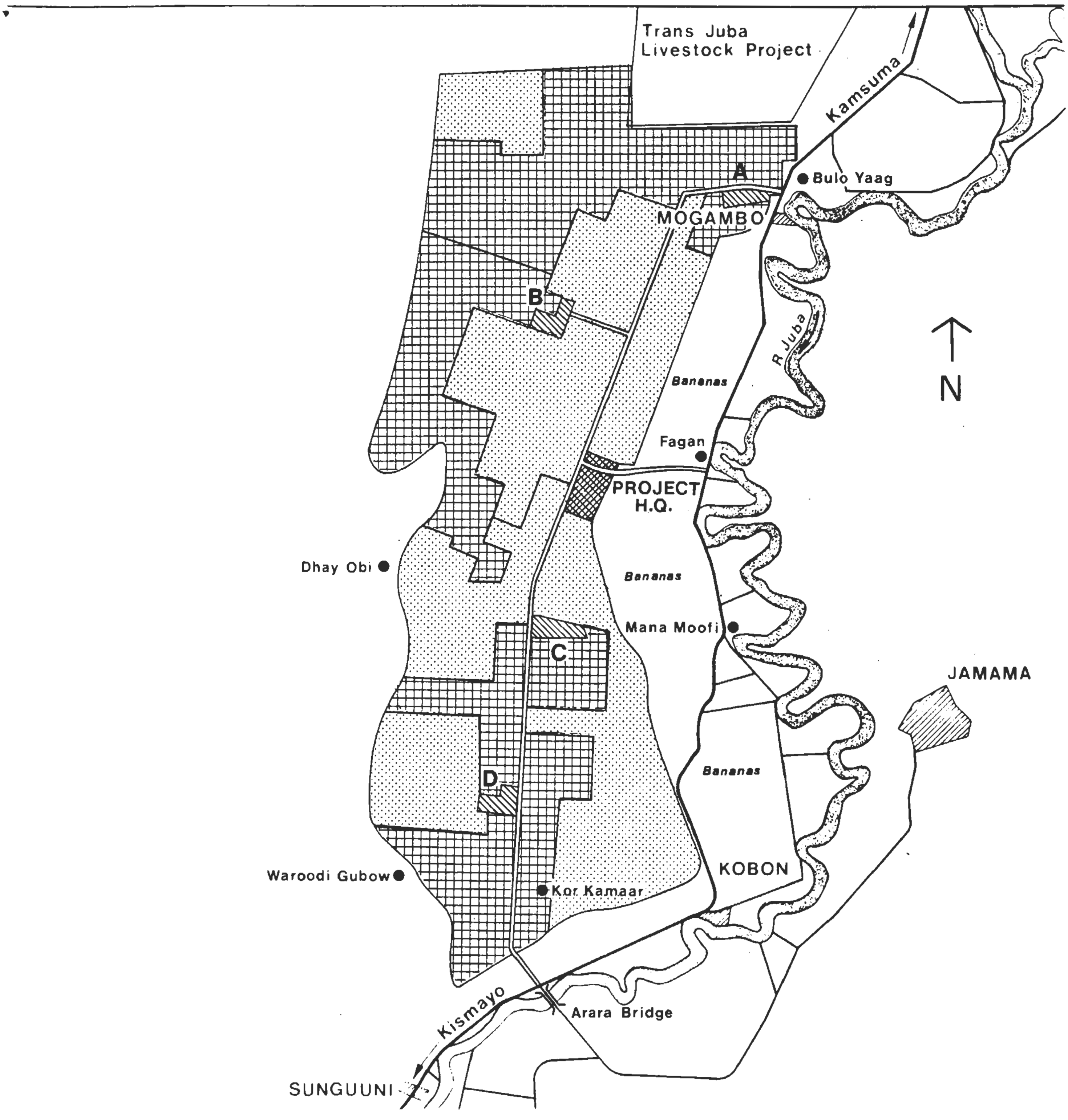
5.3 Brief Description of the Project

The project area identified from the soil and topographic surveys covers a net irrigable area of some 6 400 ha between the banana plantations to the east and the marine plain to the west.

5.1

Project irrigable areas





The soils of the project area can be divided into two broad classifications, namely the basin clays, for which surface irrigation in basins is proposed, and the meander complex levee soils, for which overhead irrigation is more appropriate. Approximately half the irrigable area will have surface irrigation and half will have overhead irrigation.

The project crops of rice, maize and cotton have been selected to give good returns and for import substitution. Bananas have been considered for the situation when perennial water availability is provided by Bardheere dam. An overall cropping intensity of 153% is proposed.

Irrigation water for the project will be pumped from the Juba river into a system of canals from which it will be diverted onto the fields of the surface irrigation system or pumped into the overhead irrigation networks. Surface irrigation will take place only during the day to limit problems of supervision, and overhead irrigation will be carried out only at night to avoid wind problems. Flood protection works have been provided to prevent the flooding of the project area which occurs at present.

The project development would take the form of a state farm and the area would be divided into four approximately equal farms, each having areas of surface and overhead irrigation. Each farm would have an associated village to house the farm workforce and each family housed therein would be provided with a small irrigated allotment. Administration of the project would be organised from a centrally located project headquarters and the day to day running would be the responsibility of the four farm managers.

5.4 Topographic Survey of the Project Area

5.4.1 Survey Requirements

The requirements of the topographic survey can be summarised as follows:-

(a) Carry out a ground survey picking up all existing features (fartas, bunds, roads, lakes, villages, etc.) and produce ground levels on a grid of approximately 300 m x 50 m.

(b) Prepare a photomosaic from existing (1963) 1 : 33 000 aerial photography.

(c) Prepare orthophotograph maps at 1 : 10 000 scale with 0.25 m form lines interpolated from the results of the level survey.

5.4.2 Surveying Techniques

A total of eight surveyors plus one field draughtsman were engaged on the site for a period of approximately three months.

The survey encompassed a total gross area of some 13 000 ha.

Main trace lines running east-west across the project area at about 1 000 m intervals followed the lines of the previous survey (TAMS/FINTECS, 1976) and were cleared by bulldozer. A main north-south trace and perimeter traces were similarly cleared. Lines between the east-west traces at 300 m intervals were hand cut with assistance from the bulldozers in the heavy bush.

Some difficulty was experienced with areas of ponded water, many of which dried out during the survey but some areas remained wet and impassable throughout the survey period.

The main east-west traces have letter references Z, A, B, C, etc. to Q, starting in the north (Figure 1.2).

Permanent bench marks were installed at about 1 km intervals. These were either concrete beacons or steel earth anchors approximately 2 m long. The permanent bench marks have been numbered in such a way as to indicate their locations on the trace lines. For example, PW4 lies on line P approximately 4 km west of the main north-south trace. Intermediate stations, which are referenced by the letter T, were placed where visibility was not possible between the kilometre points. These are of the same standard and accuracy as the kilometre beacons.

A complete list of bench marks, with co-ordinates, levels and notes on their condition at the end of the survey, is given in Annex 5 together with a plan showing the locations.

The above permanent bench marks were double levelled to an accuracy of better than 0.01 $\sqrt{k}$ m where k is the distance of the circuit in kilometres. Circuits were also closed in loop fashion to the perimeter trace. Horizontal control was achieved by the use of modern electronic distance measuring equipment and theodolites. Levels were taken at 50 m intervals along the hand cut trace lines and all detail was recorded at the same time.

5.4.3 Survey Datum

The vertical datum for the survey was based on BM 289 at Kamsuma with assumed value of:

BM 289 : 15.087 m

This value was obtained from previous survey work for the Juba Sugar project and is derived from MLB 27 at Gelib with a corresponding value of 23.977.

The adopted value for BM 289 is considered to be of a higher order of accuracy than the value supplied by the Survey and Mapping Department, Mogadishu (BM 289 = 14.731).

Confirmation of the adopted value was found in the recent survey for the Homboy irrigated resettlement project (BM 289 = 15.125).

The horizontal datum for the co-ordinate system used to locate bench marks is based on beacon A (intersection of main north-south trace and line A) with an arbitrary co-ordinate value of 50 000 m E, 50 000 m N.

5.5 Soil Survey

A systematic air photo-interpretation was carried out on the 1 : 33 000 scale air photographs of the area and a number of air photo-interpretation units identified which formed the basis for the subsequent soil survey mapping units.

Soil survey traverses were carried out using the main east-west trace lines, with the air photo-interpretation being used as a guide for the location of sites. In total, 419 observation sites were examined throughout the area, of which 78 were pits and four were termitaria descriptions, and the remainder were auger holes, 2 m deep. Augering to 5 m was carried out at 28 of the pits.

The sampling programme involved collecting four samples from each alternate bore site at depths of 0 to 0.25 m, 0.25 to 0.50 m, 0.50 to 1.00 m and 1.00 to 1.50 m, and between three and five samples by natural horizons from 35 representative pits. In addition, samples were collected every 0.5 m below 2 m from the 5 m bore sites and a selection of these were included in the routine analysis programme.

From investigation in other parts of the Juba valley (Booker-McConnell et alia) it was known that high salinity values present in the subsoil would be found in termitaria material. Hence, six termite mounds were sampled for routine analysis, four of these being located in the land levelling sample areas. Field measurements making use of a portable EC meter were carried out to confirm the presence of high salt concentration in such samples.

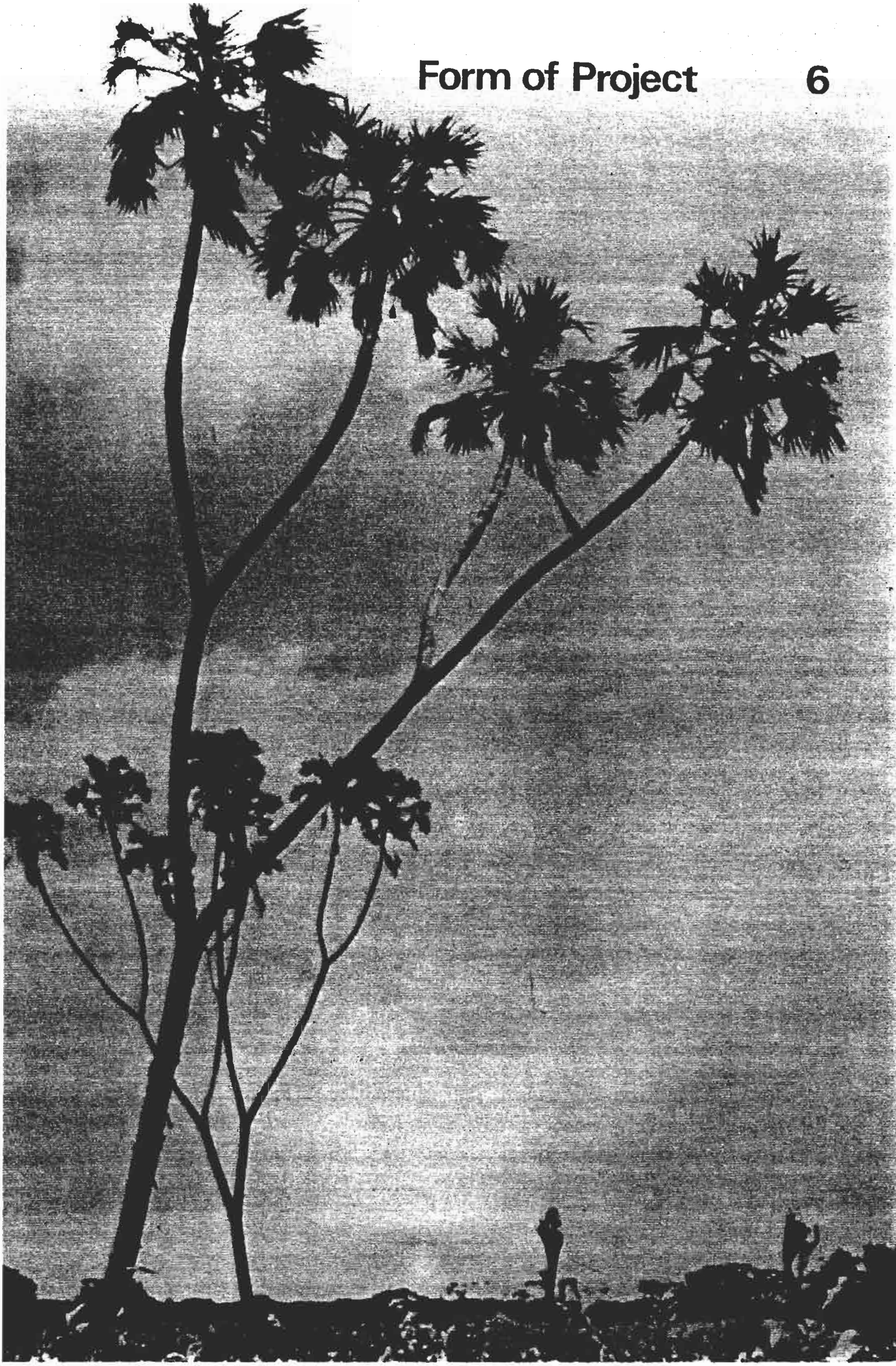
A programme of tests to determine the surface infiltration rates and the saturated vertical and horizontal hydraulic conductivities of the subsoil were carried out to cover a selection of the soil types identified. Twenty surface infiltration tests were carried out using double ring infiltrometers at representative pit locations, and hydraulic conductivity tests were carried out using a pour-in method suitable for dry soil conditions.

Experiments to determine the leaching characteristics of the project soils were carried out on four sites. At these micro-leaching test sites, metal containers were inserted into the soil and these were filled with Juba river water of known quality, the water being replenished daily. These sites were sampled at fixed depths to 1 m within the container and alongside after a two month interval. Routine analyses were carried out on the samples collected to determine the extent to which leaching of salts had occurred within the profile over the period concerned.

In addition to the formal soil survey procedures, information on land use and vegetation pattern was also collected during the course of fieldwork.

Full details of the soil survey and the results of the laboratory and field testing programmes are given in Annex 2.

Form of Project 6



CHAPTER 6

FORM OF PROJECT

6.1 Form of the Project

For a project at Mogambo to fulfil the broad objectives of the Government, it could take any one of the following four forms:-

(a) a farm corporation

(b) a group farm

(c) a settlement scheme of small holder tenants

(d) a state farm.

These alternatives are discussed briefly below.

A farm corporation is an organisation in which the participants hold shares in the corporation, the shares being in value, not in land or equipment. The shareholders must be resident and employed on the farm, which would be operated as a single unit with centralised management. The shareholders would have the right to purchase more shares in the corporation but there would be an upper limit to the number of shares which could be held by a shareholder and his family, based on a percentage of the total value. Shareholders would be paid wages appropriate to the nature of their work and the wages would be in line with existing wages for similar work. Initially the Government would be the major shareholder but over a period of years of successful operation the farm workers would increase their shareholdings. This would continue until either the farm workers had acquired the whole corporation or, if the Government wished to retain a majority interest, until the workers had acquired 49% of the shares.

The group farm concept is more familiar to the Government of Somalia. A group farm is seen as the second stage in the institutional evolution of a collective farm. It is a co-operative organisation in which the members have individual holdings which they exploit themselves but the farm is managed as a single unit owned jointly by the members. No member has any identifiable rights to a particular part of the farm or to any of its equipment or crops harvested. The farm is run by a committee and the members are required to undertake work as directed by the committee, payment being made for the work accomplished. Eventually the members would voluntarily surrender their individual holdings so that the whole farm could be collectively owned and managed. Group farms are normally formed in areas where there is already a pattern of smallholder land ownership with the Government providing additional land to form an area suitable for large farm operations.

A settlement scheme for smallholder tenants would be more appropriate for Mogambo than either a farm corporation or a group farm. The basic requisites for a group farm do not exist at Mogambo since the project area is at present largely uncultivated and unsettled. For a settlement scheme the project area would be divided into four farm units and each unit would be subdivided into plots of 2 to 4 ha.

Plots would be allocated to families under a system of priorities, the first priority going to farmers already established in the project area. The next priority would be given to farmers from the Jamama district and subsequently allocations would be made to farmers in the Lower Juba region and elsewhere.

Each of the four farm units would be constituted as a co-operative society supplying services to the tenants which would include irrigation water, canal and drain maintenance, farm machinery and equipment (on hire), farm inputs and a marketing service.

The fourth alternative, the state farm, was the form proposed in the TAMS/FINTECS report and the terms of reference for this supplementary study call for a 'critical review of the organisation and management proposed, taking into account experience in Somalia and the availability of management and labour for the project'. During meetings in Mogadishu (April 1979) the chairman of the State Planning Commission confirmed that the project should be considered within the framework of a state farm. The state farm in fact will give the greatest opportunity for maximising productivity in as short a time as possible and, as discussed in Annex 6, will be an ideal means of training and educating the workforce required for the project and for other irrigation schemes planned for the future. Details of the management structure and farm infrastucture are given in Annex 6, the basic requirements being an efficient and effective organisation and the inclusion of sufficient features to attract and retain the labour force required.

Agriculture 7

CHAPTER 7

AGRICULTURAL DEVELOPMENT

7.1 Introduction

The project area is to be developed as a large scale farm which would be owned by the state. The selection of suitable crops, proposals for cropping patterns and farming systems, agricultural inputs and general organisation of the agricultural development are summarised in this chapter. The detailed discussion supporting the conclusions drawn here is presented in Annex 3. The management structure for the scheme is discussed in Chapter 11.

7.2 Crop Selection

Until the Bardheere dam is constructed only annual crops can be grown, since the shortage of water in the dry season effectively eliminates perennial crops (Figure 7.1). However, the range of possible crops is wide and includes rice, maize, cotton, sesame, groundnuts, sunflower, sorghum, cassava, vegetables and pulses. The initial selection of crops from this wide range has taken into account the need to maximise benefits by the inclusion of high value crops, the need to reduce national imports of basic commodities (such as 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 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 the cropping patterns are rice, maize and cotton. Of the perennial crops possible after the construction of the Bardheere dam, only bananas have been selected.

7.2.1 Selected Crops

(a) Rice

The basin clay soils are particularly well suited to the cultivation of paddy rice. The construction of basins will not involve excessive land levelling and the slow draining characteristics 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. Because of its high profitability, rice will also be grown to some extent on the lighter levee soils but here it will be cultivated under upland conditions and will be rotated to avoid weed problems.

(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 import 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 with rice in terms of utilisation of machinery and equipment.

(c) Cotton

Although the history of cotton production in Somalia has been marred by the lack of skilled 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 many 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 can only be included, however, at a time when perennial water supplies are available following the completion of Bardheere dam.

7.2.2 Excluded Crops

The annual crops not included in the proposed cropping patterns are sesame, sorghum, groundnuts, sunflower, cassava, vegetables and pulses. Sesame was seriously considered for inclusion in the cropping pattern and much of the preliminary planning for this study assumed its inclusion. However the returns from this crop proved to be very low in subsequent analyses and therefore it was rejected in favour of a higher value crop. Sorghum was also rejected because of its potentially low returns. Groundnuts were considered but this crop too has relatively low returns and requires highly skilled management for harvesting, particularly when grown in heavy soils. It is also at risk from the fungus, **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 flue cured leaf and thus the managerial requirements of an inherently technically demanding crop would be even greater. Coupled with this are the shortage of fuel for 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.

Crop net margins are presented in Section 7.10 of this chapter.

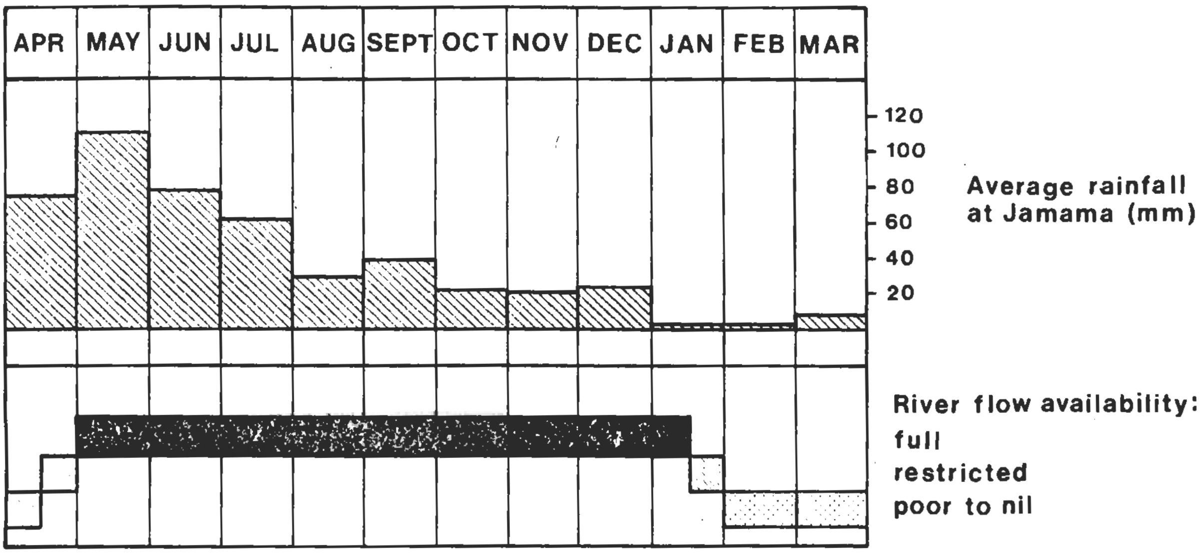
7.3 Cropping Patterns

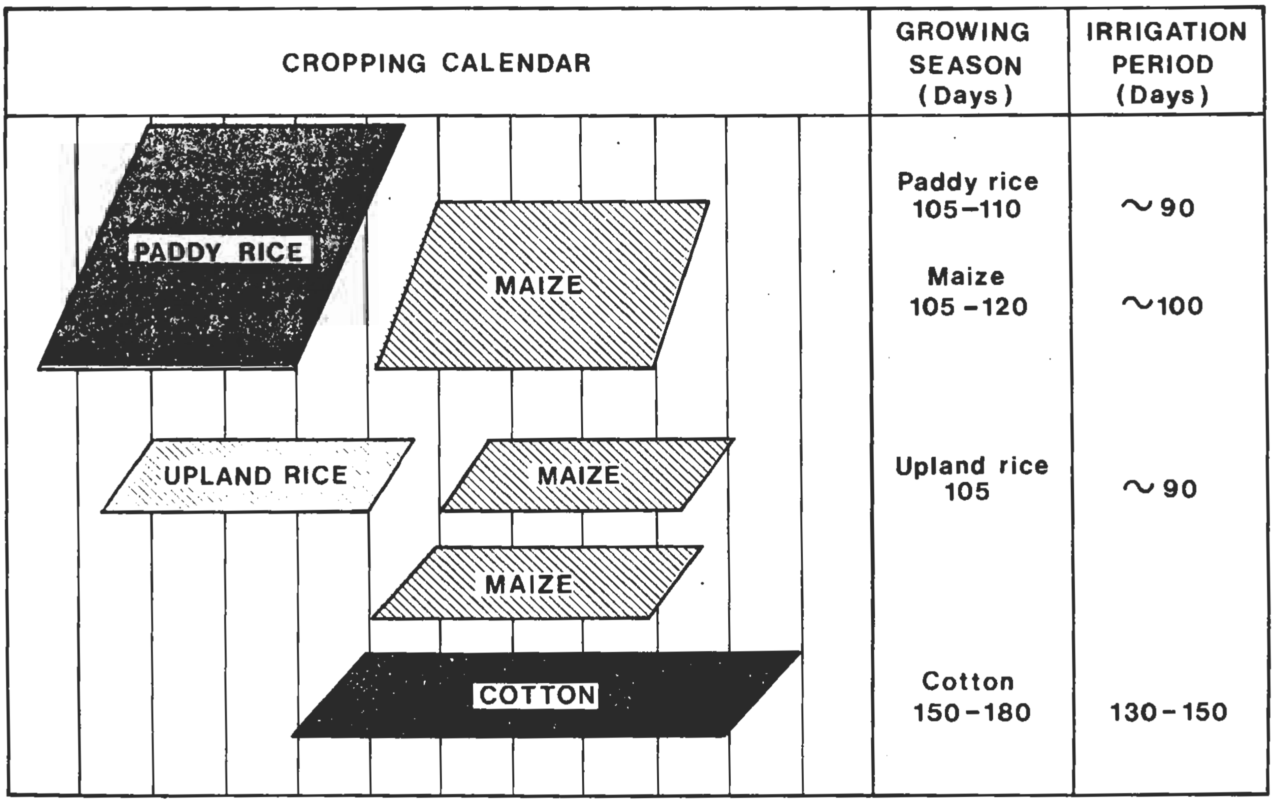
7.3.1 Without Bardheere Dam

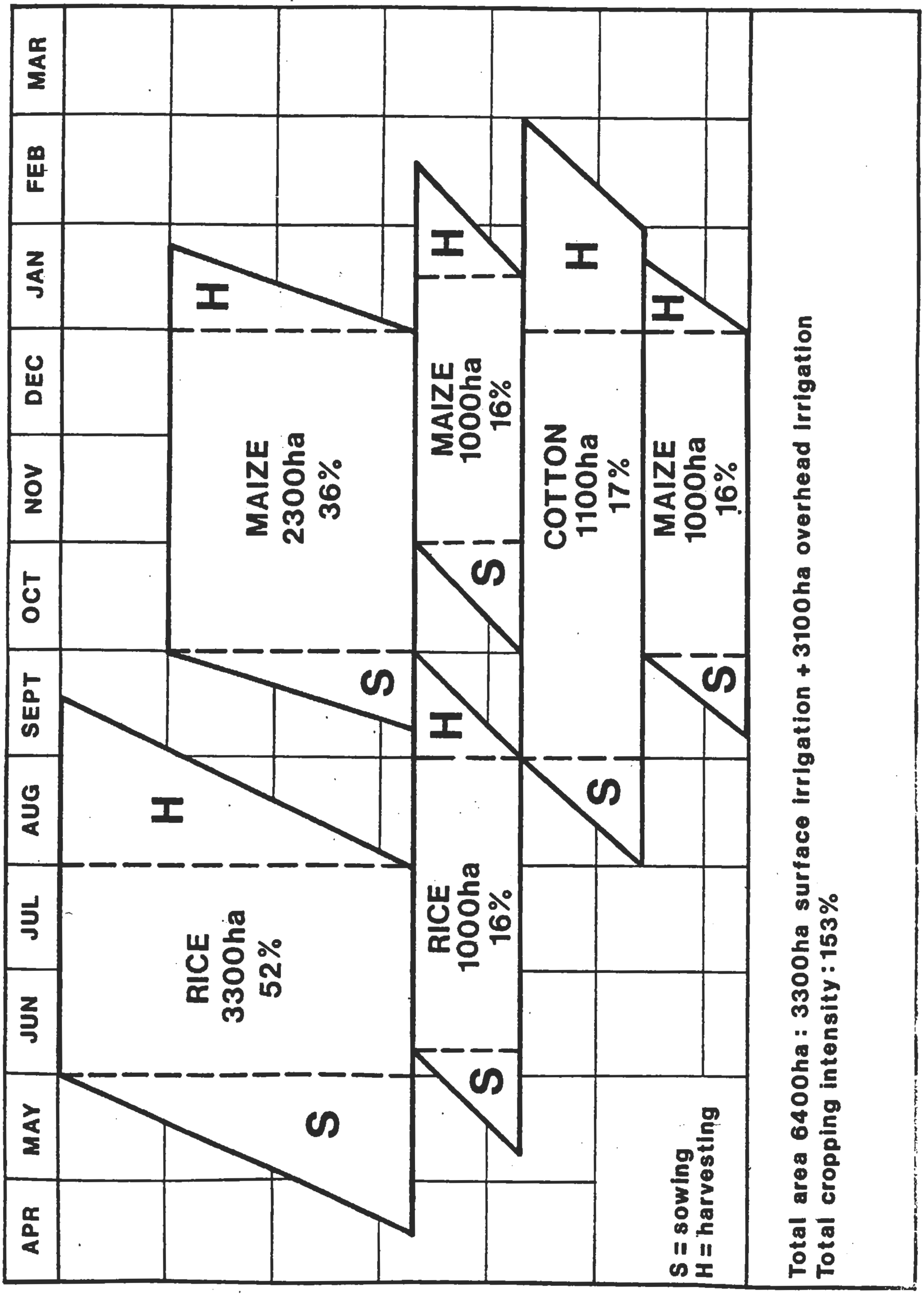
Cropping patterns have been formulated taking into account the availability of water, the influence of soils, cropping calendars and optimal growing seasons, the relative profitability of crops and their utilisation of labour throughout the year. Two patterns are proposed, one for the heavy basin clay soils which will be irrigated under a basin system, and the other for the levee soils which will be irrigated by sprinklers. The patterns are based on combinations of paddy and upland rices, maize and hand picked cotton.

Rainfall, riverflow and crop calendar relationships

7.1







Total area 6400ha : 3300ha surface irrigation + 3100ha overhead irrigation
Total cropping intensity : 153%

(a) The Clay Soils Cropping Pattern (3 300 ha net).

The clay soils, which will be basin irrigated, account for about 52% of the total net cultivable area. They are particularly well suited to the cultivation of paddy rice and, as paddy rice gives the highest returns, it is proposed that the entire area of basin soils should be devoted to rice in the gu season. This would be followed by maize in the der season over about 70% of the area. It was felt that maize on 100% of the area would be too ambitious and would lead to problems during harvesting, particularly if the preceding rice crop were to be delayed (Chapter 5).

(b) The Levee Soils Cropping Pattern (3 100 ha net).

The cropping pattern proposed for these soils comprises a mix of upland rice, maize and cotton distributed between the gu and der seasons. On these soils the cropping will be more intense in the der season so as not to conflict with the cropping intensities on the basin clay soil. The cotton crop (1 100 ha) will be grown as a monocrop followed by a period of fallow, harvesting taking place in the dry season to avoid the damaging effects of rainfall. An upland rice crop followed by maize will be grown of a further 1 000 ha and the remaining 1 000 ha will have maize only.

The relationship between the proposed cropping calendar, the availability of river flows and the incidence of rainfall is illustrated in Figure 7.1. The areas under each crop and the cropping intensities proposed are shown in Figure 7.2.

7.3.2 With Bardheere Dam

The main impact of the construction of Bardheere dam will be the availability of perennial water supplies in the river. This will enable bananas to be included in the cropping pattern for the levee soils and will allow longer seasons and hence probably higher yielding rice varieties to be cultivated. It is unlikely however that much more than 1 200 ha of bananas would be grown. This would be a significant increase on the total area already under bananas and can be accommodated with only a small increase in the design capacity of the irrigation works for annual crops. Thus there would be no need for extensive overdesign for the early stages of the scheme or to increase the capacity of the scheme after Bardheere dam was constructed.

The bananas would replace the single der season crop of maize and, if more than 1 000 ha is feasible, some of the upland rice/maize rotation.

Sugar cane was considered as a possible perennial crop but, in view of the large area planned for this crop by the Juba Sugar project, this was thought to be inappropriate. However, in the future, if the development of the Juba Sugar project does not extend to the entire planned area, the possibility of growing cane at Mogambo could be reconsidered.

7.4 Crop Water Requirements

7.4.1 General

Full details of the crop water requirements calculations are presented in Annex 3, Chapter 5. These calculations have generally followed the methods set out in FAO Paper Nr 24, 'Crop water requirements', by Doorenbos and Pruitt (1977).

7.4.2 Evapotranspiration

Reference crop evapotranspiration (ETo) estimates for each month have been based on climatological data for Gelib and Ionte, weighted in favour of Ionte which is nearer to Mogambo. The monthly design values are presented in Table 7.3.

7.4.3 Effective Rainfall

Monthly rainfall records for Jamama have been analysed to find the 1 in 5 dry month values for each month. The method used gives the rainfall value for any month which has an 80% chance of being equalled or exceeded. This method is considered more appropriate than computing the 1 in 5 dry year rainfall and distributing the annual total between the months in proportion to the monthly averages. This is because the rainfall in the project area is unreliable and erratic and the annual totals therefore conceal the true distribution throughout the year. The 1 in 5 dry month values have then been reduced to effective rainfall values as follows:

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

The resulting effective rainfall values are presented in Table 7.3.

7.4.4 Crop Factors

Crop factors for each crop for each month of the growing season have been calculated following the methods presented in FAO Paper Nr 24.

Each crop growing season has been divided into four growth periods :-

(a) initial

(b) crop development

(c) mid season

(d) late season

and crop factors assigned to these. The factors are then plotted as straight line graphs, one for the first planting date and one for the last. An average curve is then plotted giving the appropriate crop factors for each month.

TABLE 7.1

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	0.95	-	-	-	-
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(1)	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: (1) Constant average crop factor for bananas assumes planting dates staggered throughout the year.

The crop factors used in the calculation of crop water requirements are presented in Table 7.1.

The effect of a delay in planting the paddy rice crop has been considered since the availability of water in the river cannot be guaranteed in early April every year.

7.4.5 Deep Percolation Losses

Deep percolation losses have generally been included in the field efficiency terms described below but, for the paddy rice crop, a separate allowance of 5 mm/d has been allowed because this crop is grown under flooded conditions. Lower percolation rates may develop towards the end of the growth period.

7.4.6 Prewatering Requirement

For each crop an initial application of water to the fields has been allowed for. This can be applied either before or after sowing, depending on the soil moisture content at the time. Prewatering may be required to facilitate tillage of the heavy soils or to promote weed growth so that this can be dealt with prior to sowing. Allowances of between 75 mm and 150 mm have been made depending on the crop and the date of planting. The 150 mm application is for the paddy rice crop for which a saturated soil horizon is required early in the growing season.

7.4.7 Rice Flooding

The design depth of water in the paddy rice basins is 150 mm. This depth will be achieved over a period of about one month, following the growth of the rice seedlings.

7.4.8 Irrigation Efficiencies

Irrigation efficiencies have been considered at two levels - conveyance efficiency and field efficiency. The field efficiency terms are different for the surface irrigated units and the overhead irrigated units. The values adopted are summarised in Table 7.2 and discussed in detail in Annex 3, Chapter 5.

TABLE 7.2

Field Efficiencies

Crop	Surface irrigation	Overhead irrigation
Paddy rice	0.80(1)	-
Upland rice	-	0.75
Maize	0.60	0.75
Cotton	-	0.75

Note: (1) Efficiency for paddy rice does not include percolation losses.

The field efficiency terms include the following losses :

(a)	Surface irrigation :	unit channel conveyance losses uneven distribution deep percolation (except paddy rice) wastage
(b)	Overhead irrigation :	leakage from pipes evaporation (direct) deep percolation irregular distribution fringe losses.

Conveyance losses in main and distributary canals and storage reservoirs have been assessed in terms of a seepage loss, which for canals is based on the relationship :-

$$\text{losses} = 0.007\, Q^{\frac{1}{2}}\, L \quad (m^3/s)$$

where Q = canal flow (m^3/s)
L = length of canal reach (km).

The derivation of this relationship is discussed in Annex 5, Chapter 4.

7.4.9 Monthly Crop Water Requirements

The development of the monthly crop water requirements is given in Tables 5.4 to 5.8 in Chapter 5 of Annex 3. The method adopted is basically as described below.

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.

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.

7.4.10 Irrigation Requirements

The irrigation requirements are summarised in Table 7.3. The field requirements shown are the monthly net water requirements (calculated as described above) divided by the field efficiency term.

The main canal flows for each month have been derived by applying the field requirement for each crop to the total area of that crop, and summing the results, with an addition for conveyance losses. It can be seen that the peak requirement occurs in May and the corresponding main canal flow is 6.54 m^3/s.

A table comparing irrigation demand with river water availability is included in Annex 3 (Table 5.12, Chapter 5).

7.4.11 Influence of Bardheere Dam

The availability of perennial flows in the river following the construction of Bardheere dam will permit the introduction of bananas into the cropping pattern. The effect of this on the irrigation requirements has been investigated and the results are presented in Table 7.4. A longer maturing rice variety has also been introduced. It can be seen that, with bananas on 1 200 ha of the levee soils, the main canal system would have to be overdesigned from the beginning to permit the changeover to bananas at a later stage. This is discussed in detail in Annex 3, Chapter 5.

7.5 Machinery and Labour Utilisation

7.5.1 Machinery Requirements

The project will be organised as a large scale state owned farm and therefore a high degree of mechanisation is inevitable. This is mainly because large labour forces create logistical and organisational difficulties and frequently the necessary control over timeliness of completion of work and the quality of work produced is impossible to achieve, even assuming that labour in such quantities is available. This is particularly important where a highly intensive cropping programme such as that proposed for the project is envisaged. Since existing schemes such as Juba Sugar project are already experiencing difficulties in hiring labour there is in any case some doubt about the overall availability of labour in the area. This is discussed in more detail in Annex 6.

It is recommended therefore that all land preparation, fertiliser distribution and planting operations are mechanised. Weed control would be achieved by mainly mechanised means including aerial spraying of herbicides and mechanical cultivation. It is unlikely however that complete control can be achieved by these means alone and provision has been made for the use of some hand labour for knapsack spraying and for hand weeding of isolated areas. Pest control can also be achieved mainly by aerial spraying supported by spot spraying using motorised knapsack sprayers for control of isolated outbreaks of pests.

Harvesting of rice and maize will be mechanised. A basic combine harvester which can be modified between seasons to deal with either crop is proposed. Cotton would be hand picked but a trial programme on 100 ha for the introduction of mechanical picking is also provided for. The system which would be given immediate priority would be 'stripper' picking which relies on the use of a less sophisticated machine, but has the disadvantage of requiring pre-cleaning before ginning.

TABLE 7.3

Summary of Irrigation Requirements

Month	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 (1 000 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) Rice grown under overhead irrigation is upland rice. Surface irrigated rice is paddy rice.

TABLE 7.4

Irrigation Requirements - Option for Situation with Bardheere Dam

Month	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)	-	-	-	-	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.

In choosing appropriate machines for the project, preference has been given to more robust equipment with a high output. Every effort has been made to reduce the range of equipment to the minimum and to avoid highly specialised machinery. The main power units have been reduced to three types of tractor (one tracked and two wheeled) and land preparation has been standardised for most crops and reduced to three operations.

Aerial spraying of herbicides and insecticides is proposed since the alternative of hand spraying would be extremely labour intensive and less easily supervised. However, the purchase of spray aircraft solely for the project cannot be justified and therefore contract aerial spraying is proposed. This can be a very cheap method of applying herbicides and insecticides and in the future there will be an obvious need for such services throughout the Juba valley. This could be organised in Somalia under the overall control of the Juba Valley Development Authority, when formed.

The various mechanised operations for each crop are summarised in Table 7.5 and the build up in machinery requirements to full development of the project is given in Table 7.6. It is expected that the number of driver/operators required will increase from 30 in year 2 to 155 at full development in year 5. This assumes that machinery will be worked in two 6 hour shifts per day and includes 25% for trainee drivers.

TABLE 7.5

Mechanised Field Operations by Crop(1)

Field operation	Basin soils		Levee soils		
	Gu rice	Der maize	Gu 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 following land levelling (basin soils) or after bush clearance and removal of termitaria (levee soils)

(3) To establish temporary bunds for water distribution

TABLE 7.6

Machinery Requirements to Project Maturity
(numbers)

	Year			
	2	3	4	5
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

Source : Annex 3, Table 3.10

7.5.2 Labour Requirements

Despite the fairly high degree of mechanisation a large labour force will still be required to cope with operations such as irrigation, bund and furrow maintenance, spot weeding, spot spraying of pests, loading and handling seed, fertiliser and crops produced. In addition cotton picking will create a considerable demand for labour (100 man days per hectare) during the picking season from mid-December to February. The estimated build up of the labour force for direct agricultural operations alone between years 2 and 5 is summarised in Table 7.7. The permanent labour force is expected to rise from around 130 members at the end of year 4, ready for full implementation of the project in year 5.

TABLE 7.7

Summary of Monthly Demand for Agricultural Labourers during Project Years 2, 3, 4 and 5

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
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
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
5	318	899	940	940	857	1 044	1 268	1 092	1 226	1 979	1 057	321	

The introduction of 1 200 ha of bananas after construction of Bardheere dam would cause the labour force to be more than doubled; 1 200 ha of bananas would require around 1 500 labourers throughout the year to cope adequately with the crop.

7.6 Implementation

The proposed implementation of the project is discussed in detail in Chapter 13 of this volume and also in Annex 6. Brief details are included here for completeness.

The project area has been divided into four farms each of which has an associated village to house the labour force and their families. Each farm comprises a proportion of clay and levee soils. The net cultivable area of each farm is given in Table 7.8.

TABLE 7.8

Net Cultivable Area of Each Farm

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

The project would be developed over a five year period with the first areas of crops being cultivated in the second year. Throughout this period the area under production would be built up and cropping intensity gradually increased. The expected build up in cropped area between years 2 and 5 is shown in Table 7.9.

7.7 Machinery Support Services

The supporting services for machinery comprise a comprehensive workshop and mechanical store at the project headquarters, daily maintenance facilities at the four project farms and two mobile workshops.

Considerable emphasis has been placed on training for both mechanics and driver/operators. A combination of practical training through working as counterparts with experienced and highly skilled staff, and more formal courses arranged through the project training department and manufacturers of equipment, is proposed.

TABLE 7.9

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)

7.8 Farm Buildings

A main warehouse for reception and storage of incoming goods would be located at project headquarters. It would be a general purpose building with about 1 080 m^2 floor space. Each farm would have its own office, storage space and hardstanding areas for tractors and machinery. Tractors, combine harvesters, combine drills and fertiliser distributors would be kept under cover in open fronted sheds whilst the remaining equipment would be kept in the open on hardstanding. A total of 1 200 m^2 of hardstanding has been provided, distributed equally between the four farms. Farm buildings are discussed in more detail in Annex 5, Chapter 6.

7.9 Crop Processing and Storage

Facilities have been provided at project headquarters for drying, storage and hulling of rice. Maize would generally require no drying but if necessary the grain drying plant has sufficient capacity to cope. Figure 7.3 shows the layout of the processing and storage facility which would also house a small seed preparation plant and acid delinting plant for cotton seed.

7.10 Net Margins

'Net margins' have been calculated for the crops identified as agronomically suitable in Annex 3. The 'gross margin' is the traditional criterion used to compare crop profitabilities, and consists of the difference between gross returns and the costs of direct inputs. However, in the case of the proposed state farm at Mogambo, comparing crops on the basis of gross margins would obscure the disparate requirements of each crop for machinery (for example, machine picked cotton), unskilled labour (bananas) and processing facilities (rice). These costs have been included in the calculation of the net margins.

Table 7.10 shows the net margins at financial and economic values.

TABLE 7.10

Crop Net Margins

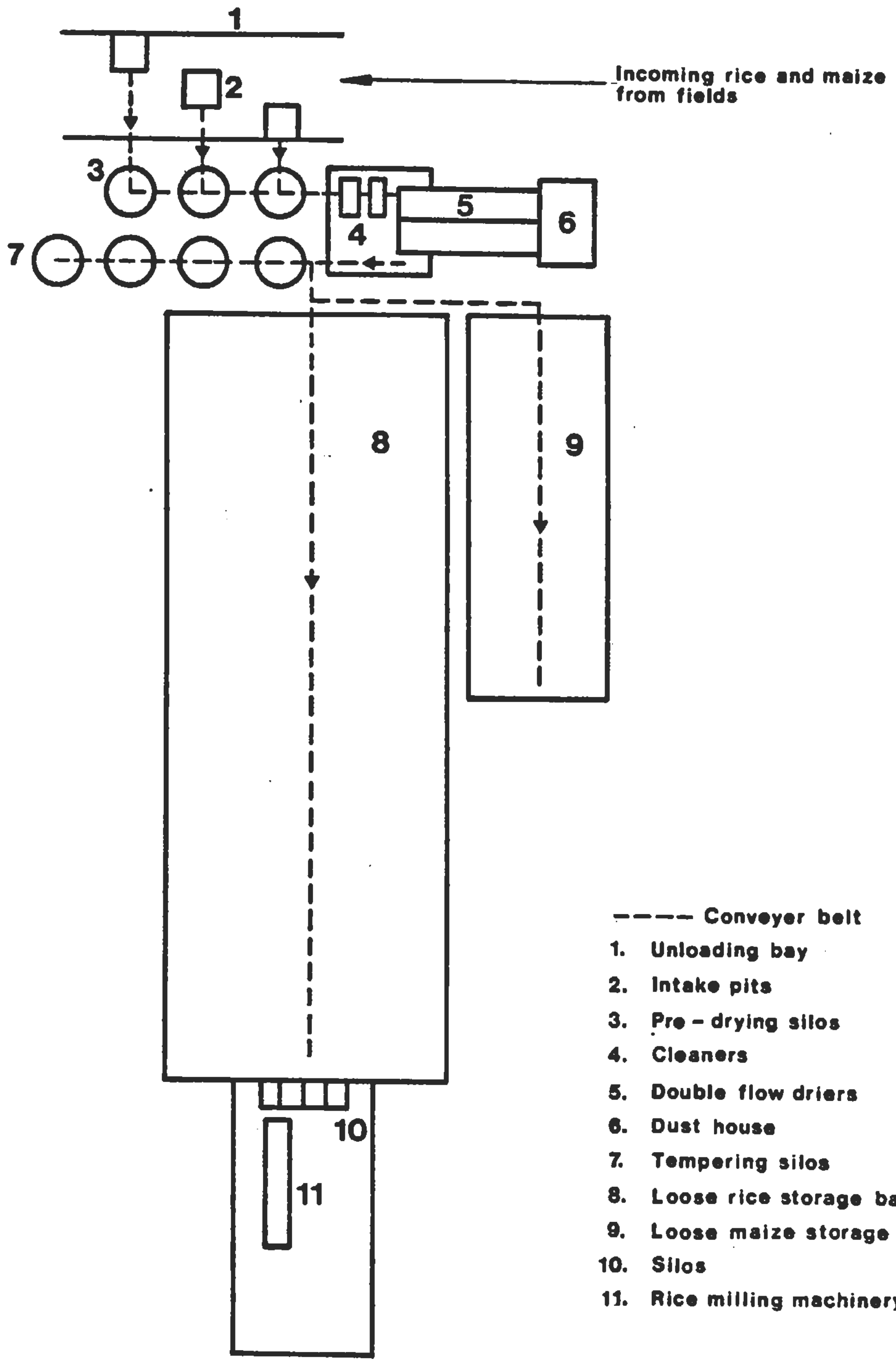
Crop	Net margin (SoSh/ha)	
	Financial	Economic
Paddy rice	9 482	6 409
Upland rice	7 917	5 257
Maize - surface	1 238	2 368
Maize - sprinkler	1 330	2 435
Sesame	47	811
Cotton - hand harvested	3 245	4 550
Cotton - machine harvested	1 880	2 753
Bananas (average over 6 years)	4 464	9 631

The rices constitute the most profitable crops. In economic terms, cotton is nearly as profitable as upland rice, but occupies a whole crop year whereas upland rice can be double cropped with maize. Bananas show the highest net margin, roughly equivalent to a paddy rice-maize combination.

Sesame shows very low returns owing to the limited yield response to irrigation water.

Grain dryer and rice mill layout

7.3

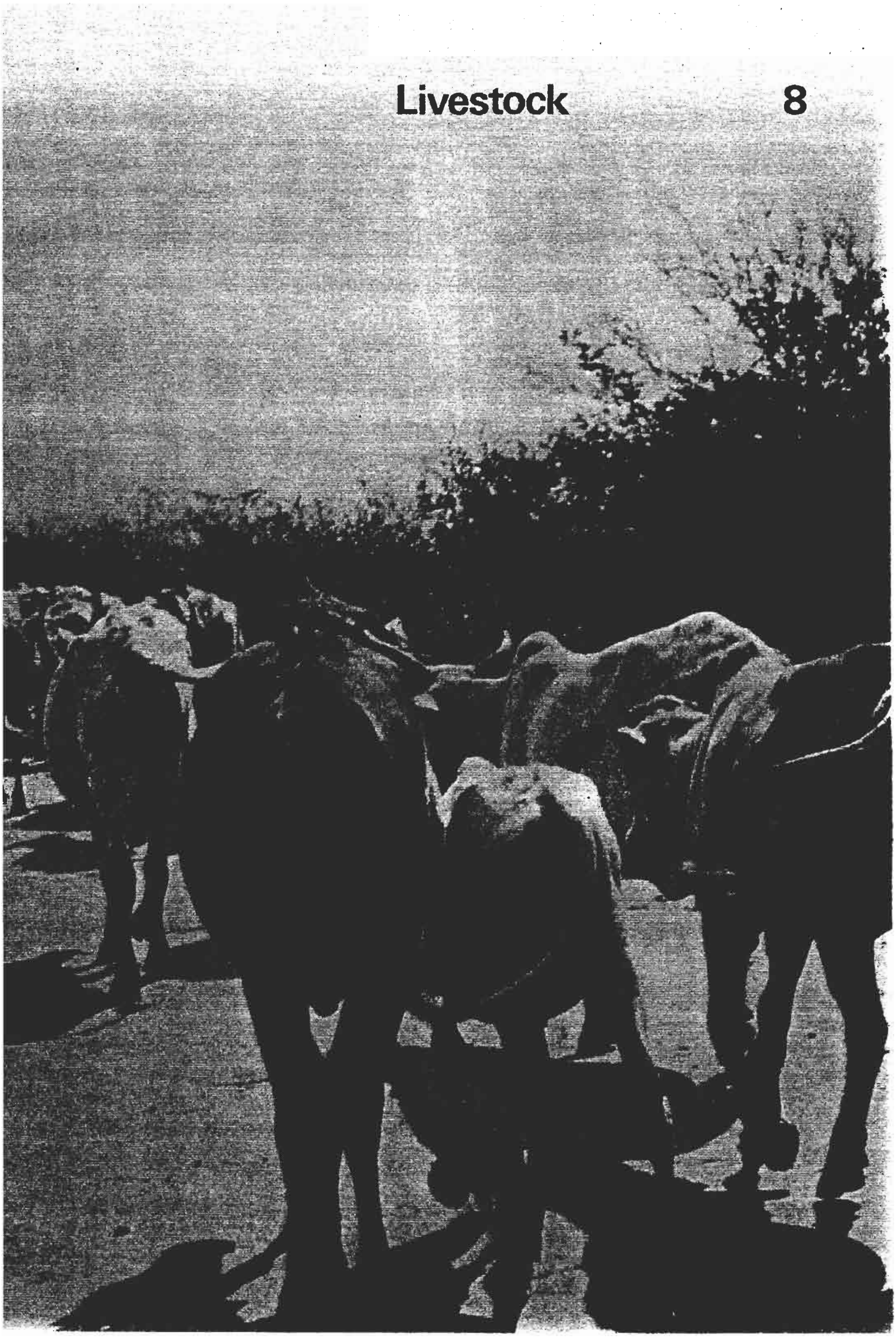


---- Conveyer belt

1. Unloading bay
2. Intake pits
3. Pre - drying silos
4. Cleaners
5. Double flow driers
6. Dust house
7. Tempering silos
8. Loose rice storage bays
9. Loose maize storage bays
10. Silos
11. Rice milling machinery

Approximate scale 1:1000

Livestock 8



CHAPTER 8

LIVESTOCK

8.1 Introduction

The TAMS/FINTECS (1977) proposals for the Mogambo project included a beef feedlot which would fatten some 30 000 cattle each year on a ration based on irrigated fodder and crop residues. The cropping pattern proposed in this supplementary study differs from the TAMS/FINTECS proposals and irrigated fodder will not be grown at Mogambo. The three main crops that will be grown under the new cropping pattern, maize, rice and cotton, all produce crop residues and by-products, some of which can be used for the intensive fattening of cattle. In view of this, and the prospect of molasses from the Juba Sugar project, proposals have been prepared for a beef feedlot at Mogambo. These proposals, which are presented in detail in Annex 4 of the report, analyse the technical, managerial and economic aspects of such an enterprise.

Livestock production is the main industry in Somalia and is the principal source of the country's foreign exchange earnings, and Government policy is firmly directed towards improving the scope and level of animal production. However, local experience of feedlot production in Somalia is very limited.

Three other existing projects would have an influence on a feedlot in the Mogambo project. These are the Juba Sugar project, producing molasses as a by-product; the Kismayo Meat Factory and the Trans-Juba livestock project, particularly the marketing component thereof.

8.2 Production of Crop Residues and By-products at Mogambo

The Mogambo feedlot would be based on crop residues and by-products resulting from the irrigated crop production activities of the project.

The cropping pattern proposed for Mogambo would produce rice straw and hulls, which are not suitable as a fattening ration, maize stover which is useful as a high-fibre feed, and cotton seed cake which is a valuable high protein livestock feed. In addition to these, a feedlot ration would require molasses, maize grain and sesame seed cake. The availability of cotton seed cake is dependent on the establishment of a local oil extraction plant. It is estimated that, at full implementation, the following quantities of residues and by-products would be available:-

Maize stover	9 300 tonnes (dry matter)
Cotton seed cake	950 tonnes (dry matter)
Rice straw	4 500 tonnes (dry matter)

8.3 Availability of Cattle

Feedlots require a reliable, regular supply of relatively cheap unfinished animals. The exact age and size of the most suitable animals will depend on the type of ration and the market preference for finished animals. Table 8.1 gives cattle population estimates for the three regions from which the Mogambo feedlot would obtain animals.

TABLE 8.1

Estimated Cattle Population in Southern Somalia

Region	1975	1979 estimate
Lower Juba	860 800	1 171 108
Middle Juba	291 000	395 902
Gedo	411 900	560 385
Total	1 563 700	2 127 395

There are no accurate data on commercial offtake rates for cattle in Somalia, but the total number of animals which might be available from the three regions lies between 32 000 and 85 000 cattle each year.

Although the Kismayo Meat Factory (KMF) is not at present slaughtering cattle, it has a capacity to kill 60 000 animals/year. Whether the KMF draws slaughter stock direct from the rangelands or whether it would be able to utilise feedlot fattened beasts depends on whether it can develop an export market for chilled carcasses which would be essential for economic feedlot operations. The total annual demand for cattle in the three regions including domestic demand, live export and feedlot requirements might be 114 700 if the KMF was operating at full capacity or 84 700 it if was operating at half capacity.

If the figures for offtake and demand are accurate, it is possible that there could be a problem in obtaining sufficient animals, which would be further complicated if the feedlots were to fatten animals for the live export market, as there is a ban on the export of females and only males could be put through the feedlot.

Livestock marketing in the Juba area is the responsibility of the LDA, though there are several private traders who are licensed to operate in the area. LDA operates two holding grounds, one at Gelib and another at Afmadu as part of the Trans-Juba livestock project. LDA will improve the existing stock routes. Both prices and the number of animals on the market vary with the season. During the rains the supply of animals drops and the price increases. As the dry season progresses, however, the number of cattle available increases and the price drops.

Data have been collected on both local purchase prices and the value of export quality animals. Local purchase prices are estimated to range from SoSh 3.50 to 5.33/kg liveweight. The lower value probably represents dry season prices, and at the time of the fieldwork (May/June 1979) actual purchase prices were between SoSh 4.80 to 5.33/kg liveweight. The SoSh 5.33/kg is particularly important as it is the price quoted by LDA as their current minimum selling price. This is the price that they would require in order to provide the Mogambo feedlot with cattle. The value of cattle on the export market or for quality finished stock ranges from SoSh 5.40 to 6.25/kg liveweight. The results of a recent World Bank/FAO marketing study indicate that average FOB Kismayo value is SoSh 5.90/kg liveweight.

8.4 Animal Production and Nutrition

The daily gains that are achieved in a feedlot depend on the quality of the ration and the age, type and condition of the cattle being fed. Work elsewhere in Africa has indicated that lean, large framed cattle are capable of reasonable weight gains, even if they are fed a relatively high fibre ration. In Somalia there is little experience in the use of high fibre rations as most of the work done in the MLFR feedlot has been based on feeds using a high proportion of rice and wheat bran.

The dominant breed in the Juba area is the East African Boran. This zebu (**Bos indicus**) animal has been shown to perform well under feedlot conditions.

Production estimates (Table 8.2) have been based on an assumed average daily weight gain of 0.7 kg which is considered to be a reasonable average gain for a large scale commercial operation with the type of feed available.

TABLE 8.2

Production Estimates for Mogambo Feedlot

Fattening period	90 days	120 days
Average weight at entry	230 kg	230 kg
Average daily weight gain	0.7 kg	0.7 kg
Average weight at exit	293 kg	314 kg
Average total weight gain	63 kg	84 kg

The estimated nutritional requirements, based on an animal weighing 260 kg receiving a dry matter intake of 6.5 kg/d are:-

Total digestible nutrients (TDN)	-	4.58 kg/d
Digestible protein (DP)	-	0.47 kg/d
Estimated net energy (ENE)	-	30 MJ

8.5 Feedlot Rations

The nutritional value of eleven different possible rations was calculated in order to assess which permutations of the different feeds would be the most suitable at Mogambo (Annex 4, Table 5.3). Details of four possible rations which were selected are given in Table 8.3. Two of the rations (numbers 5 and 6) contained no supplement of maize grain while the other two (numbers 7 and 10) included a maize grain supplement.

TABLE 8.3

Selected Feedlot Rations

	Ration 5	Ration 6	Ration 7	Ration 10
			Percentage dry matter	
Maize stover	40	40	50	40
Concentrate cake	30	20	20	15
Molasses	30	40	20	25
Maize grain	-	-	10	20
Percentage deviation from theoretical nutritional requirements				
TDN	- 5.0	- 5.2	- 5.0	+ 0.4
DP	+ 66.2	+ 14.9	+ 28.9	+ 10.8
ENE	- 1.9	- 5.0	- 6.4	+ 2.2
Cost per tonne FW (SoSh)				
	345	301	318	363

Ration 10, the most expensive per animal of the selected four, is the only one to meet all the three criteria for nutritional requirements. All potential rations meet the protein requirements but rations 5, 6 and 7 fall short in the supply of TDN and energy. In none of these rations, however, is the difference greater than 7%. Practical trials will be required to determine growth rates and costs.

The total number of animals which could be fed by each ration varies and depends on which residue is the limiting factor and which duration of feeding is used. A shorter feeding period will obviously mean that more animals would pass through the feedlot. The maximum number of cattle that might be handled each year is 16 950, using a 90 day period for ration 10. A more realistic figure, however, would be 10 000.

8.6 Rate of Development

The limited local experience in feedlot production indicates the need for a gradual phased rate of development. This would not only enable some of the basic assumptions used in this report to be tested but would also permit the training of suitable staff and the development of effective feeding techniques and management systems. •

Three phases of development would be appropriate:

Phase I:	Initial feeding trials to determine which of the four selected rations would be the most suitable and establish realistic production parameters. This would be carried out at the MLFR feedlot at Mogadishu
Phase II:	A pilot feedlot to establish feeding and management systems and to provide practical training for staff. This could start in year 2 of the project and would run for three years with an annual turnover of some 1 000 cattle
Phase III:	Commercial feedlot development. This would follow on from Phase II and at full development would hold 5 000 cattle at a time with an annual turnover of 10 000 cattle.

It would require an eight year period before full commercial development is achieved.

The purchasing and sale of cattle in the numbers required for the commercial feedlot would require a very high degree of organisation. The most obvious source of unfinished cattle is the LDA which will also be supplying the Trans-Juba livestock project's feedlot and the Kismayo Meat Factory. The smooth and efficient operation of the Agency's marketing activities would be essential to the eventual success of the feedlot.

8.7 Economics

A 20-year financial model was drawn up according to the production parameters already identified, and using 1979 prices. It was assumed that the pilot feedlot would operate from project year 2 to 5, and the commercial feedlot would start construction in year 5 and operations in year 6. The same exercise was carried out using economic values, and the two models are summarised in Table 8.4.

In constructing the economic model, taxes and duties were removed from purchased goods, unskilled labour was shadow priced at SoSh 8/d and the economic cost of maize grain was substituted for the financial. Of the other feeds, maize stover would not be imported, and the concentrate cake, minerals and molasses prices were already based on world prices. The same cattle purchase price of SoSh 5.33/kg and range of sale prices were used for the economic as well as financial cases since Somalia is already competing with world producers for the Arabian market.

Only at a selling price of SoSh 6.25/kg does the feedlot generate a positive internal rate of return over 20 years, and this sale price is only available in a limited premium market in Mogadishu. At the most realistic price assumption of SoSh 5.90/kg, the feedlot barely covers its financial costs, and makes an economic loss.

The lack of viability of the proposed feedlot is due to the small difference between the buying and selling prices, no price premium for quality beef, absolute price levels geared to low-cost Somali producers, and non-availability of low cost feeds. However, the result is in line with world trends since very few viable feedlots are now operating anywhere.

TABLE 8.4

Summary of Results of Feedlot Model (SoSh '000)

	Financial	Economic
Initial capital costs	11 631	10 508
Annual stock purchases at full development	12 505	12 505
Annual feed costs at full development	3 210	4 065
Other annual operating costs	1 386	1 174
Total annual operating costs	17 071	17 744
Annual Returns(1) at SoSh 5.40/kg	16 310	16 310
Annual Returns at SoSh 5.90/kg	17 820	17 820
Annual Returns at SoSh 6.25/kg	18 877	18 877
IRR at sale price of SoSh 5.40/kg	-ve	-ve
IRR at sale price of SoSh 5.90/kg	1 98	-ve
IRR at sale price of SoSh 6.25/kg	12.86	7.98

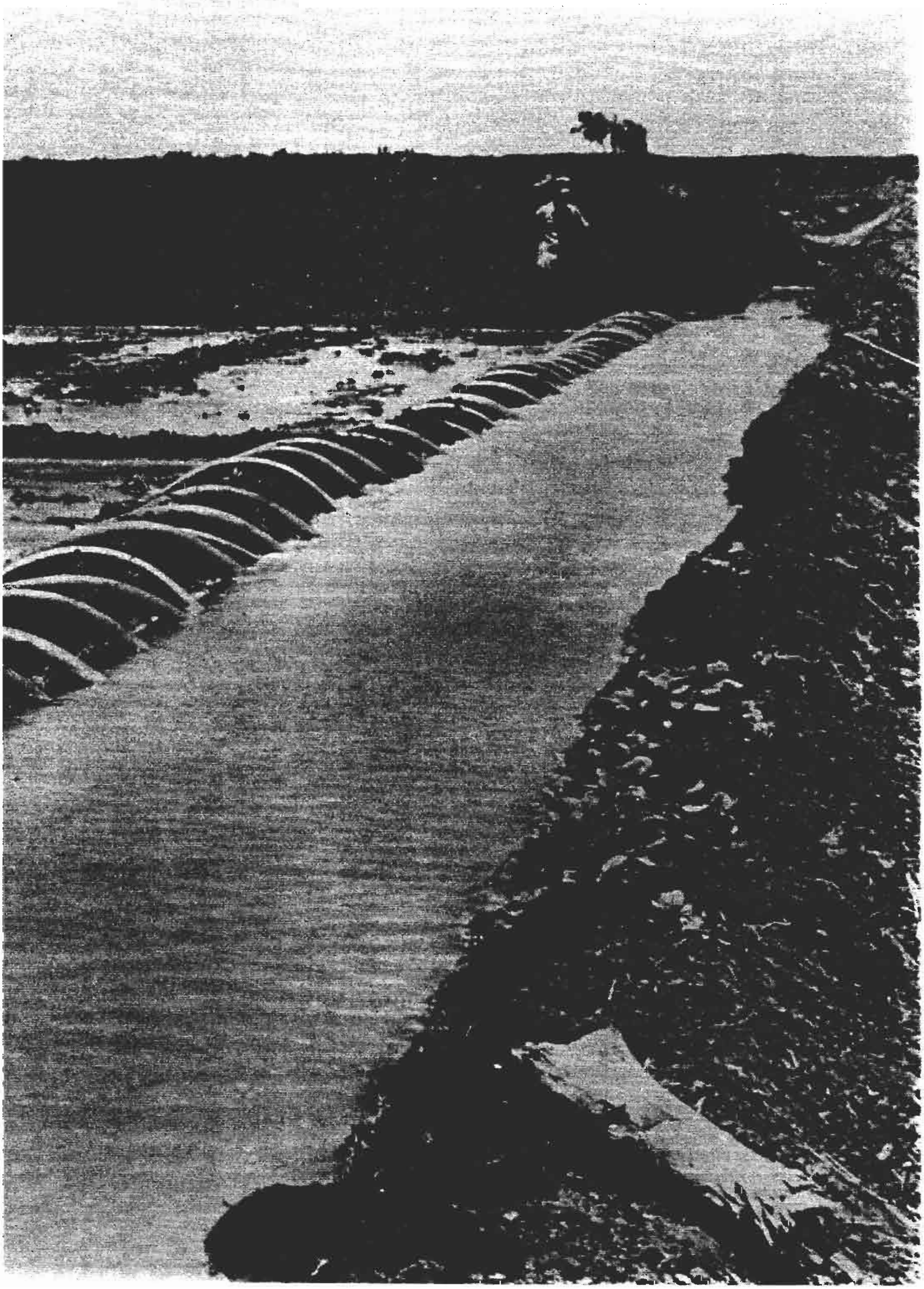
Note: (1) At full development

8.8 Development Alternative

In view of the poor economic returns of a feedlot for the Mogambo project its inclusion is not recommended.

As an alternative to constructing separate feedlot facilities at Mogambo, the possibility of expanding the Trans-Juba feedlot, making use of crop by-products and residues from Mogambo should be given careful consideration, as it should lead to reduced costs and improved efficiency.

Engineering 9



CHAPTER 9

IRRIGATION AND DRAINAGE ENGINEERING

9.1 The Irrigation System

9.1.1 Identification of the Project Irrigable Area

The boundaries of the irrigable area were partially defined during the fieldwork and finalised during the preparation of the irrigation and drainage layouts.

In the north the project boundary is defined by the southern boundaries of the Trans-Juba livestock project and the future development area for the Juba Sugar project. To the east and south the existing banana plantations form the project boundary. However some land, which according to available maps showing property boundaries, is owned by banana growers has been incorporated in the project, but only where this land has never been cultivated or has been left uncultivated for a number of years.

The western project boundary is defined by the depressional areas and drainage channels adjacent to the marine plain. In determining the limits of the project irrigable area on the western edge, low lying areas which would be very difficult to drain have been omitted. One area of about 100 ha has been omitted because it is to the west of a large natural drainage channel.

Within the project boundaries two systems of irrigation have been proposed, surface and overhead. The boundaries between surface and overhead irrigated areas have been kept straight wherever possible so as to simplify access and farm operations. In doing this it has not, of course, been possible to follow rigidly the boundaries of the land classification units. The policy has generally been to provide overhead irrigation for those areas classed as 4s (see Annex 2) but since these mapped areas are very irregular in shape the overhead irrigation units have encompassed other land classes. This was considered preferable to providing surface irrigation for areas of mixed land class and topography since the control of water distribution across the land will depend on accurate levelling and fairly consistent soil type. However it has not always been possible to achieve this and some surface irrigated areas have mixed soils.

The total gross areas encompassed by the project boundary is approximately 8 000 ha, which can be broken down as follows:

Category	Area (gross ha)
Surface irrigation units, 3 300 ha net	4 000
Overhead irrigation units, 3 100 ha net	3 200
Area for villages and project headquarters including for future expansion	200
Reservation for flood relief channel and main channel	150
Storage reservoirs	50
Natural drainage channels and other depressional areas	400
TOTAL	8 000

The two systems of irrigation have been chosen to suit the soils and topography of the project area. The systems are :-

(a) surface irrigation

(b) overhead irrigation (sprinkler)

Surface irrigation generally involves less capital cost than sprinkler irrigation and therefore sprinkler irrigation has been chosen only for those areas where the topography and soil strata are such that the quantity of earthmoving required for land levelling would be uneconomic, impracticable or would result in the exposure of undesirable soil sub-layers.

The method proposed for surface irrigation is basin irrigation, which is particularly appropriate for the rice crop and enables it to be grown under paddy conditions. The basin method of irrigation is also proposed for the maize crop which follows rice, although this crop will not be grown under flooded conditions.

The sprinkler irrigation system proposed is a lateral move system with buried mains and sub-mains.

The layout of the irrigation and drainage system is shown on Figure 9.1 and, in more detail, on Plates Nr 35 to 38.

9.1.2 The Field Unit

(a) Surface Irrigation

The surface irrigation field unit is illustrated in Figure 9.2. The standard unit has a net area of 27 ha divided into 1 ha basins each of which is levelled to a horizontal plane. Adjacent basins may have the same level, depending on the original microtopography of the field unit.

The unit channel, with a design capacity of 90 l/s, serves the unit through three branches of the same capacity each supplying nine basins.

Surface drainage water from the unit is carried away by shallow unit drains, which have 1 in 8 side slopes to permit the passage of agricultural vehicles.

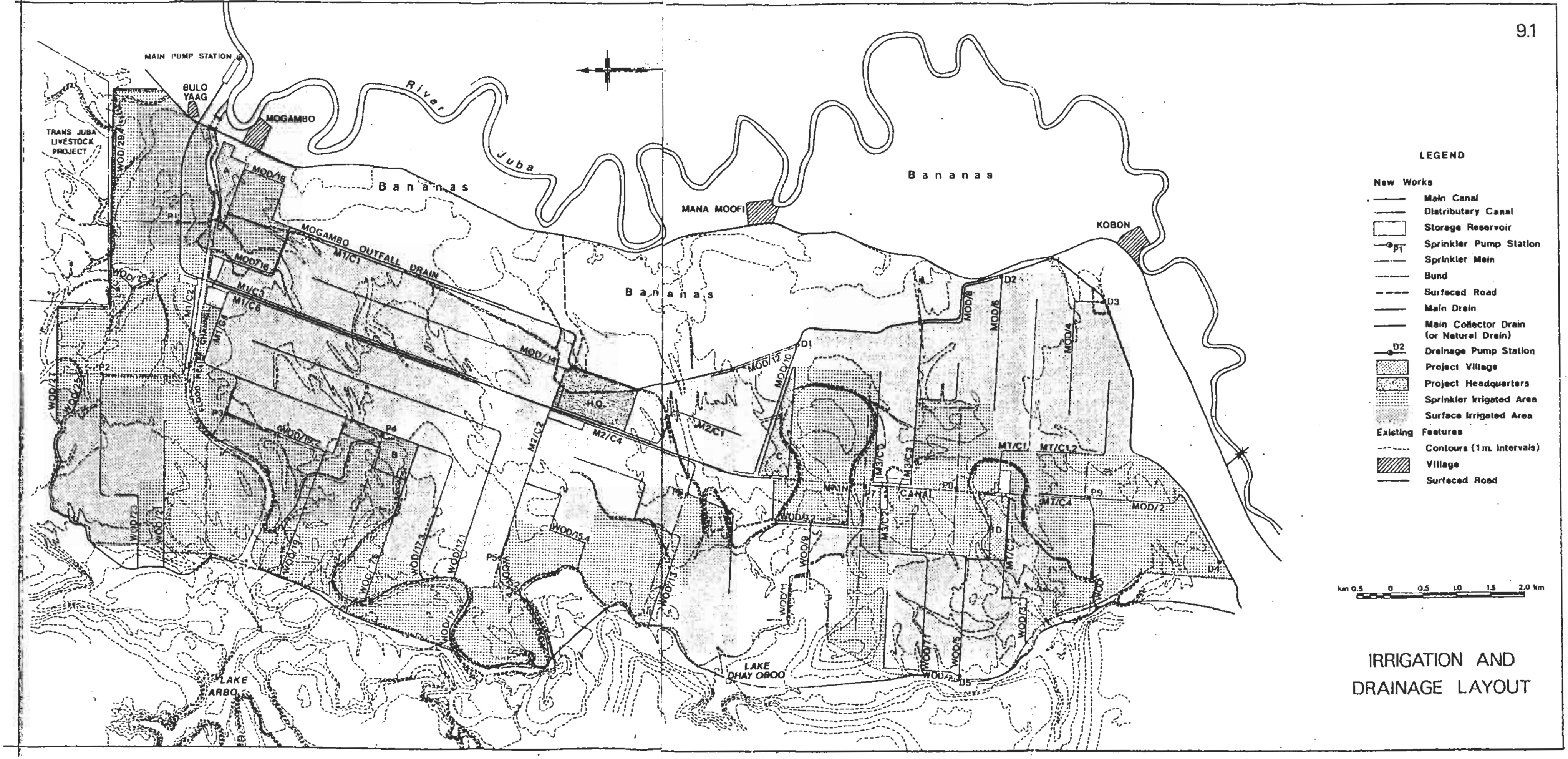
Major access routes are along the embanked roads parallel to the main collector drains (6.0 m wide) and access into the unit is provided by 4.5 m wide unit roads at ground level.

(b) Overhead Irrigation

The overhead irrigation unit is composed of two equal half-units, each served by a buried sub-main. The half-unit is illustrated in Figure 9.3.

The half-unit has a net area of 20.4 ha which is served by 12 hydrants on the sub-main, each of which feeds a lateral in three positions. The lateral (and hydrant) design discharge is 5.8 l/s.

Surface drainage from the unit relies generally on the natural drainage channels within the area but this is augmented by unit drains where necessary, particularly for isolated low areas.



IRRIGATION AND DRAINAGE LAYOUT

Access within the overhead irrigated areas follows the boundaries between units where a 10 m road reservation has been allowed. Within the unit there are 4.5 m wide roads at ground level.

9.1.3 Field Irrigation

(a) Surface Irrigation

Water is conveyed from the unit channel through plastic siphon pipes which are primed by hand. These siphons divert the whole discharge of the unit channel into one basin at a time and a total of 22 pipes is required to achieve this for the design flow of 90 l/s with minimum command. At times of lower demand or where command is higher, fewer siphons will be needed. The water level in the unit channel must be maintained during this process otherwise the siphons will lose prime. This is achieved by a portable check which is simply inserted in the channel section at the downstream end of the basin. This same device can also be used to effect the diversion of the unit channel at the appropriate branch.

The reasons for irrigating one basin at a time are briefly described below and discussed in detail in Annex 5, Chapter 4. Basically this system gives the highest rate of water application which will be required to ensure an even distribution over the basin for those crops not grown under flooded conditions. The alternative of feeding two or three basins simultaneously has the additional disadvantage of higher labour rate to supervise the siphons (one man per basin). It would also require permanent division structures on the unit channel branches although these branch channels could be of smaller section.

The design application rate is 130 mm gross applied in four hours at nine day intervals. This is based on the monthly maximum gross requirement for rice (444 mm in May). Smaller applications for rice and other crops are achieved by the same means but with a lower discharge in the unit channel and with fewer siphon pipes in operation. Depths of application of less than 50 mm will not occur. Should the crop water requirements be lower than this, the irrigation interval can be increased. Indeed, in the case of the maize crop it may well be possible to increase the interval to 15 days or even 18 days depending on the rooting depth and soil moisture capacity. This can be achieved easily with the system proposed. The choice of the nine day cycle was based on the assumed deep percolation loss of 5 mm/d for the rice crop. This, together with an evapotranspiration of about 5 mm/d, means that the ponded water depth drops from 150 mm just after irrigation to about 60 mm immediately prior to the next irrigation. Shallower depths than 60 mm would not achieve the aim of weed control. The deep percolation rate may well be less than 5 mm/d particularly towards the end of the rice season in which case the irrigation interval can be increased.

(b) Overhead Irrigation

Operation of the overhead irrigation system is simple. During the day the laterals are disassembled into their component 6 m lengths (every third one having a sprinkler riser), moved 18 m to the next postition, reassembled and connected to the hydrant. The following night the sprinkler pump stations are started up and irrigation commences. Minimal supervision will be required during the irrigation period. An attendant will be required at each pump station (two shifts of 6 hours) and the Irrigation foreman will be required to check that all the sprinklers are operating satisfactorily at the start of the irrigation.

Night-time only operation of the sprinkler irrigation system is proposed since high winds can be experienced during the daylight hours which would result in poor distribution and reduced efficiency. This is discussed in detail in Annex 5, Chapter 4 and the economics of the proposed system are compared with a 23 hour system.

The design application rate is 90 mm gross applied in 12 hours at 12 day intervals (a rate of 7.5 mm/h). This is based on the maximum monthly gross requirement for the cotton crop (232 mm). Smaller application rates are achieved by either increasing the irrigation interval or by reducing the time of the irrigation to less than 12 hours.

The 12 day irrigation interval is based on an assessment of 80 mm of moisture in the root zone (1.0 m deep for cotton) which is readily available to the crop. This implies a maximum interval of 14 days before there is any likelihood of the crop suffering from a water shortage.

9.1.4 Irrigation Distribution System

Irrigation water is pumped from the Juba river into a settling basin and thence into the main canal. The settling basin is designed to drop out the majority of particles with a diameter greater than 0.06 mm, and much of the remaining suspended sediment (the wash load) will drop out in the storage reservoirs. The majority of bed load consisting of medium and coarse sand, which can cause damage to the pumps, will be dropped out in a short intake channel between the river and the pumps.

The main canal is designed to run continuously at a discharge which is maintained constant for periods of up to one month. This ensures that the operation of the canal is simplified and also minimises the size of the canal.

Since the surface irrigation system operates only during the day there is a need for storage of the main canal flow at night. Some of the night-time flow will, of course, be required for the overhead irrigation system but, at the time of peak surface irrigation requirements, the overhead irrigation requirements are much lower. Two systems of storage were examined:

(a) storage in the distributary canals

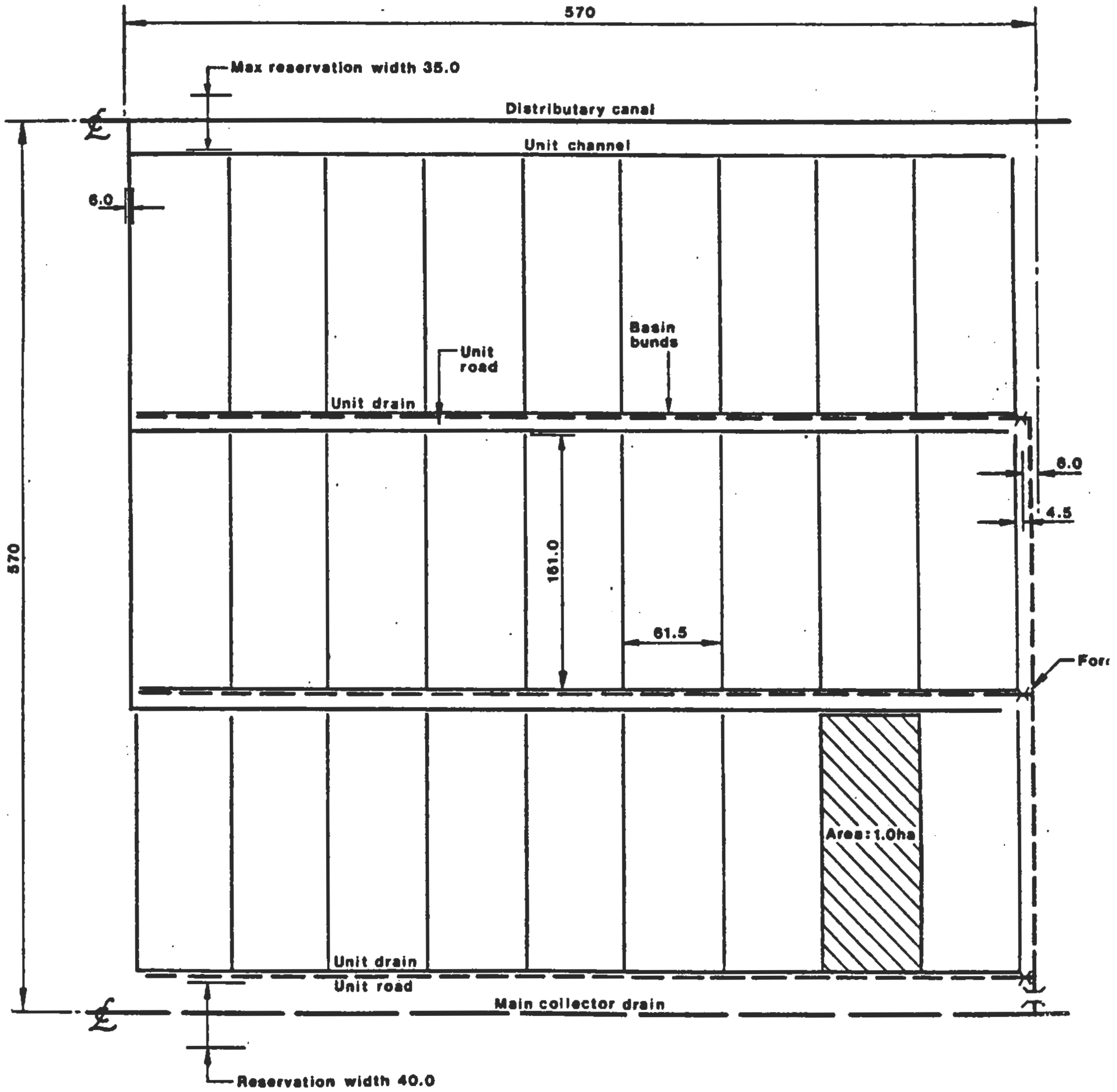
(b) storage in reservoirs at the heads of the distributary canals.

The reservoir system of storage was selected (see Chapter 4 of Annex 5) mainly because there was little cost difference between this and in-canal storage, and the reservoir system is easier to operate and maintain.

Water is diverted from the main canal into the reservoirs through movable weir regulator structures. The same structures are used as cross regulators on the main canal to maintain a constant level upstream. The movable weir is readily calibrated for discharge measurement, and the measurement is accurate for up to 70% submergence.

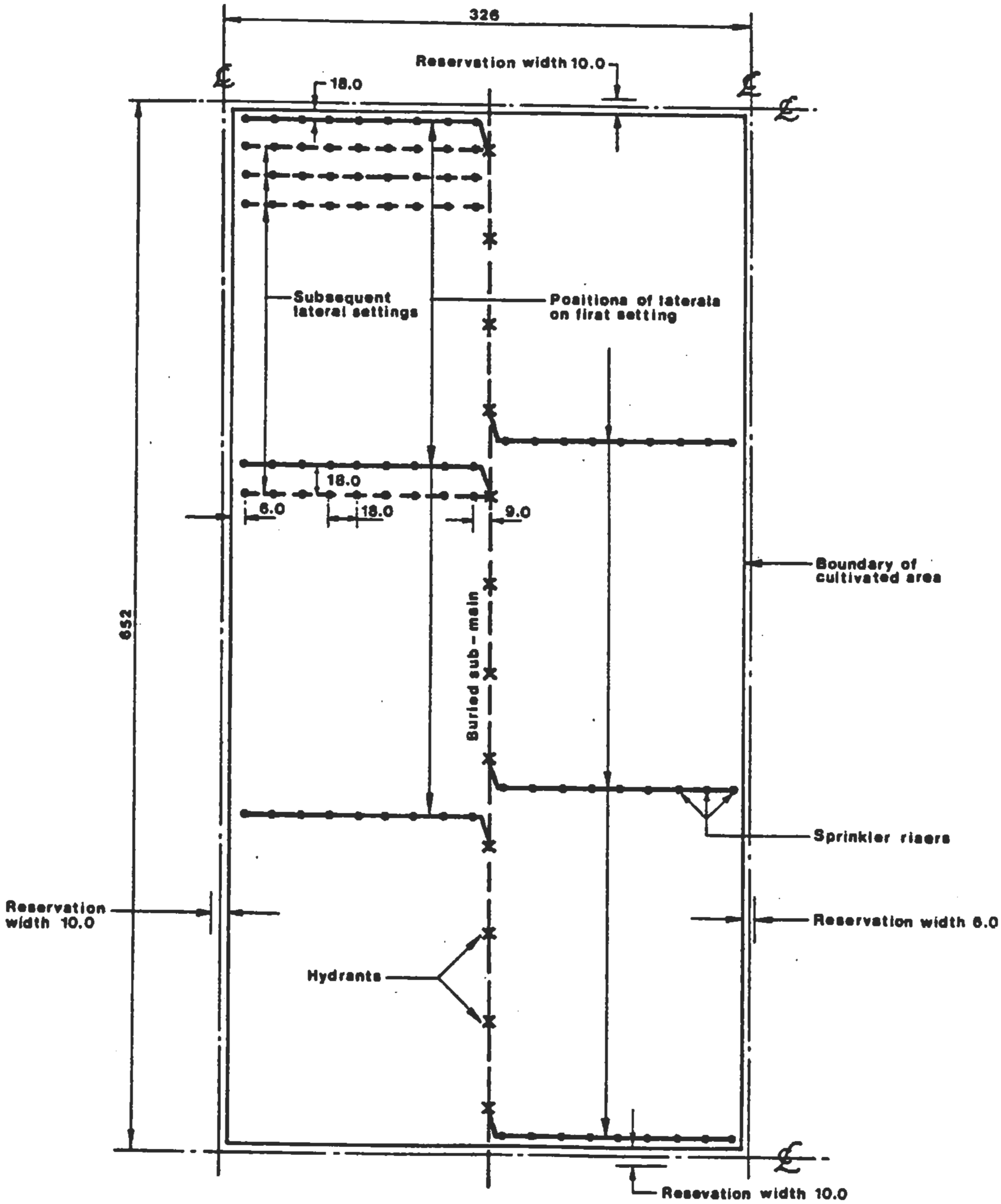
The reservoirs can serve up to three distributary canals each. The distributaries off-take from the reservoirs through gated pipe regulators and the discharge is estimated from a water level gauge downstream of the regulator.

Typical surface irrigation unit



Approximate scale 1:400

Typical overhead irrigation half unit



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The gated pipe regulator has been used in preference to a movable weir since it is much less sensitive to upstream water level changes and therefore will require less frequent adjustments. Cross regulators on the distributary canals are also gated pipe structures and are designed to maintain water level at groups of off-takes and at sprinkler pump stations.

The off-takes which serve surface irrigation units are similar to the gated pipe structure except that the pipe is of a standard size and the gate is a hinged disc gate rather than a lifting gate.

Sprinkler pump stations have been located in the nearest canal to the overhead irrigation area concerned so as to minimise the cost of expensive distribution main. Three pump stations are located on the main canal, the remainder on distributary canals.

Full details of typical structures are shown on Plates Nr 45 to 50 and these are described in Chapter 4 of Annex 5.

9.1.5 Canal Design

Canals have been designed in accordance with Lacey regime theory which was formulated to give canals which neither suffered from excessive silt deposition nor had problems of scour. The basic equations are:-

$$S = \frac{0.0003 e^{1/3} f^{5/3} E}{Q^{1/6}}$$

where S = water surface slope

Q = canal discharge (m^3/s)

e = width factor $= \dfrac{Ws}{4.83Q^{1/2}}$

Ws = water surface width (m)

E = wetted perimeter divided by Ws

f = silt factor $= \dfrac{2.46\ V^2}{Dm}$

Dm = sectional area divided by Ws

A width factor (e) of 0.83 and a silt factor (f) of 0.50 have been used.

The design flow in the main canal has been based on the water requirements of the month of May, which is the peak month for the paddy rice crop. At this time there is also an upland rice crop on 1 000 ha of the overhead irrigated area and this has been assumed to be in those areas at the tail of the main canal so that the worst case is catered for. A diagrammatic representation of the main canal is given in Figure 9.4, showing the design flow requirements for May as described.

Typical canal cross-sections are shown on Plate Nr 42 and the main canal longitudinal section on Plate Nr 40.

Canal freeboard has been based on the relationship:-

$$F_b = 0.20 + 0.15Q^{1/3}$$

with a minimum value of 0.40 m. Values of less than 0.40 m would only be appropriate for distributary canals but the 0.40 m minimum has been maintained so that the distributary canal tail escapes can operate without reducing the freeboard to an unacceptable value.

Canal design criteria are summarised in Table 9.1.

TALBLE 9.1

Canal Design Criteria

Criteria	Canal Type		
	Main	Distributary	Unit
Maximum design flow (m^3/s)	6.50	1.57	0.115
Minimum design flow (m^3/s)	1.38	0.18	0.09
Maximum depth of flow (m)	1.40	0.87	0.65
Minimum depth of flow (m)	0.83	0.42	-
Maximum bed width (m)	8.20	4.00	-
Minimum bed width (m)	3.80	1.40	-
Maximum water surface slope (m/km)	0.102	0.34	2.00
Minimum water surface slope (m/km)	0.074	0.10	0.10
Channel side slopes	1:2	1:2	1 : 1.5
Freeboard above design water level (m)	0. 50 - 0.40	0.40	0.20*
Bank top width (m)	5.0	4.00	-
Minimum bend radius	10 x water surface width		5.0

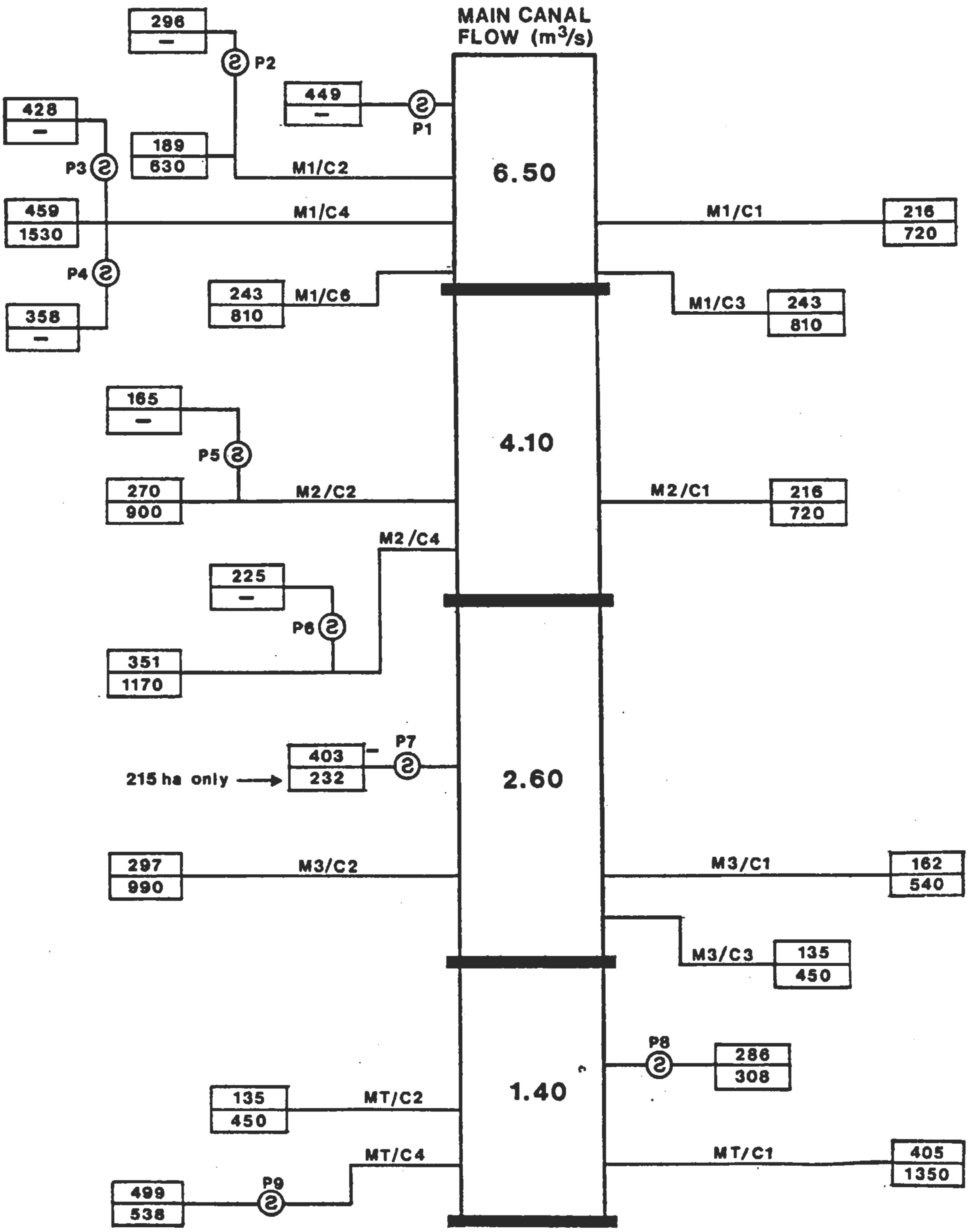
Note: * Minimum

9.2 Land Levelling Requirements

Land levelling is of fundamental importance to the success of any surface irrigation scheme. If the accuracy of land levelling is low it will prove impossible to achieve an even distribution of water across the fields and, as a result, the efficiency of the system will drop dramatically. In order to assess the land levelling requirements of the project area, eight sample areas (300 m x 300 m) were surveyed on a 25 m grid. These areas were chosen to

Main canal design flows for May

Legend: 135 = Net area (ha); 450 = 12 hour flow (l/s) excluding conveyance losses



represent the variety of soil and topographic conditions prevailing in the project area but excluded land which was obviously unsuitable for land levelling. Their locations are shown on Plate Nr 2.

The results of these land levelling sample surveys have been analysed using a computer program to determine the earthmoving requirements for various systems. A minimum plot size of 1.0 ha was assumed since the land levelling of smaller units, although possible, is neither practicable nor economic with the type of equipment proposed. In the clay basin soils, where paddy rice will be grown, only basin irrigation was investigated (level basins). For the levee soils four irrigation methods were investigated: basin, border strip, furrow and overhead. The slope requirements for the three surface irrigation methods are given in Table 9.2, overhead irrigation does not require land levelling. Using these constraints the same areas were examined in detail for a variety of possible sizes and slopes of land levelled area.

TABLE 9.2

Slope Requirements for Land Levelling

Irrigation method	Major slope (%)	Minor slope (%)
Basin	0.0	0.0
Furrow	0.015 to 0.2	- 0.2 to 0.2
Border strip	0.015 to 0.2	0.0

For the basin clay soils it was found that generally the land levelling requirements were reasonable with maximum depths of cut and fill less than 0.5 m and the quantities of earth moved less than 500 m^3/ha, although area Nr 6, which had defined microtopography, had a requirement of 775 m^3/ha. This was not generally true of the levee soils although some of the levee soil areas had relatively even topography and land levelling would be a practicable proposition. However, the depth of the soil is more variable in the levee areas and there is a greater risk of exposing sand lenses or saline layers. Also the areas of levee soils generally have much more broken topography and there are frequent old channels dissecting the area. It was decided therefore to adopt overhead irrigation for the levee soil areas and surface irrigation in level basins for the basin clay soils. Land levelling requirements were estimated at 450 m^3/ha for areas with M1 and M2 micro-relief and 775 m^3/ha for areas with M3 micro-relief. Full details of the land levelling requirements are given in Annex 5.

The method proposed for land levelling for Mogambo uses laser controlled elevating scrapers and motor graders. This has been shown by considerable experience to be the best combination leaving little room for error. The control system can be fitted to most models of modern earthmoving machinery.

The motor graders, which have twin receivers and controls to adjust both the height and cross slope of the blade, shave off the surface layers from the high points leaving ribbons of spoil. These are subsequently picked up by the scrapers and the material deposited in low areas to be finished off level by the graders. The elevating attachment on the scraper enables it to load its bucket full and to take shallow cuts as required.

9.3 Bush Clearance

Bush varies in density across the project area from very dense with large numbers of trees and closely spaced bush and scrub, to open cultivated land with only isolated trees.

Plate Nr 2 shows the approximate extent of the natural vegetation across the project area and the estimated areas under four categories are given in Table 9.3.

TABLE 9.3

Natural Vegetation in Project Area

Classification	Gross area (ha)	% of total
Dense bush	1 480	18
Medium bush	2 537	32
Light bush	2 759	34
Open (including cultivated land)	1 289	16

Note: It should be noted that some of the areas classified as light bush encompass areas which have been cultivated.

The whole of the irrigable area will have to be cleared of bush prior to the construction works, although isolated trees of size should be left in place, particularly in village areas and the project headquarters.

The material resulting from the bush clearance will be sorted and stockpiled into material suitable for building and that for firewood or charcoal preparation. Stockpiles should be located adjacent to the centres of population in the project area for future use. A substantial quantity of material suitable for village house construction may result from the clearance.

The method proposed for bush clearance is a front mounted multi-application rake on a crawler tractor followed by root ploughing. This will ensure that the root bowl and the majority of major lateral roots will be removed with the minimum disturbance to the ground.

9.4 Drainage System

9.4.1 General

Drainage systems in irrigation schemes generally take two forms depending on whether the prime function is surface or sub-surface drainage. A surface drainage system is designed to remove from the fields run-off resulting from rainfall and also, to a lesser extent, excess irrigation water. A sub-surface drainage system is needed where there is a problem of a rising groundwater table which is in danger of waterlogging and/or causing salinisation of the root zone with consequent reduction in yield or, in extreme cases, crop failure.

9.4.2 Surface Drain Design

The drainage rates for the Mogambo area have been computed for a return period of 5 years, both for the surface irrigated areas and the overhead irrigated areas. The surface irrigation units have basins which are level and which are bunded, thus forming a built-in storage system. Under these conditions the drainage rate is reduced and is determined such that the depth and period of flooding are acceptable to the crop concerned. For young rice seedlings this is based on the need to prevent drowning of the seedling; in mature rice this is not a problem. For maize, which is sensitive to flooding, the criterion is the length of time for which flooding will last. A drainage rate of 1.5 l/s/ha was found to be appropriate.

For the sprinkler irrigation units there is no surface storage and if rainfall occurs at a time when the soil is saturated, run-off will be immediate and rapid. A drainage rate of 3.5 l/s/ha is proposed. Details of the derivation of these rates are given in Chapter 5 of Annex 1.

The drainage system has thus been designed to discharge the flows resulting from the above rates. The smallest drain, the unit drain, is just a shallow vee-shaped depression with 1 in 8 side slopes to allow the passage of agricultural traffic. This drain collects drainage water from the surface irrigation units and augments drainage in the sprinkler units where drainage from the natural landform is relied upon to a large extent. Spoil from the excavation of the unit drain helps to provide the material required for the unit feeder channels.

Unit drains discharge into collector drains which are trapezoidal in section. These flows into main collector drains and finally into the two outfall drains on the western and eastern boundaries.

The eastern boundary drain (Mogambo outfall drain) drains the project area east of the main canal and also the banana areas on its left bank. The western outfall drain follows the old channel system between the project area and marine plain.

Disposal of the drainage water from the project area presents a problem. Basically this water will move southwards following the natural ground slopes and old channel systems until it finds its way to the large expanse of water known as Dhesheeg Waamo. Some minor earthworks will be required to ensure that the water flows in the required direction and does not back up into the project area. However, although the route of this flow can be determined, the level at which it operates is fixed by the existing ground levels and the water level of Dhesheeg Waamo. Unfortunately this requires a water level at the southern end of the project which is too high to permit gravity drainage of the entire project area. As a result, some of the drains in the lower lying areas have to be pumped into the outfall drains. In total five drainage pump stations are required, serving approximnately 30% of the project area.

Drain design criteria have been summarised in Table 9.4

TABLE 9.4

Drain Design Criteria

Criteria	Outfall	Main collector	Unit
	Drain type		
Maximum design flow (m^3/s)	6.45	2.25	0.05
Minimum design flow (m^3/s)	0.62	0.10	0.05
Maximum depth flow (m)	1.50	1.25	-
Minimum depth of flow (m)	0.70	0.35	-
Maximum bed width (m)	11.0	3.8	-
Minimum bed width (m)	2.1	0.8	-
Maximum water surface slope (m/km)	0.53	1.50	2.00
Minimum water surface slope (m/km)	0.09	0.15	0.05
Channel side slopes	1:1.5	1:1.5	1:8
Bank top width (access road) (m)	6.0	6.0	-
Minimum bend radius	10 x water surface width		5.0

9.4.3 Sub-surface Drains

The need for a sub-surface drainage system is impossible to assess without a comprehensive survey of the groundwater and aquifer conditions in the project area. Nevertheless, it is possible, with the information obtained during the study fieldwork and the proposals for irrigation, to estimate the likely effects of the project on the water table. This has been carried out and the details are given in Annex 5, Chapter 5.

The calculations suggest that the likelihood of a sub-surface drainage system being required in the early life of the project is remote. Furthermore it is quite possible that no problems will occur during the entire life of the project. Nevertheless a groundwater monitoring system should be installed as part of the project so that adequate warning of a groundwater problem is given in the event of this occurring.

Problems associated with salinity of the irrigation water or with the existing salinity of the soil have been demonstrated to be negligible. The downward movement of irrigation waters will be sufficient in quantity to ensure the effective leaching of salts beyond the root zone.

The rate of rise of the groundwater table is more difficult to predict since it depends larely on the extent and continuity of aquifers below the root zone. There is evidence to suggest that these aquifers may well have sufficient continuity to maintain a balance of inflow and outflow such that a rising water table does not present a major problem.

It is therefore proposed that no sub-surface drains are installed as part of the project works.

9.5 Flood Protection

9.5.1 General

The main cause of flooding within the project area at present is the operation of the flood escape structure at Bulo Yaag just north of Mogambo village. This escape structure is used to remove a percentage of the river flow, reducing the water levels downstream of the structure at times when the river is in flood. Thus lands adjacent to the river, especially the banana plantations, are given protection from the rising flood water. The escape structure is also used to pass water into the project area as a crude form of flood irrigation for farmers to grow crops on the residual moisture.

The escape structure has an estimated capacity of about 100 m^3/s but the channel downstream of the structure has silted up and is overgrown so that at present effective capacity is much reduced.

Two possible proposals for the future of this escape have been considered and costed (Annex 5) and these are:-

(a) Rehabilitate the structure (which is in good condition) and enlarge and extend the channel such that it can pass 100 m^3/s through the project area to the western drainage system.

(b) Close the escape structure permanently.

9.5.2 Project Proposals

It has been decided that it is desirable to keep the Bulo Yaag escape structure open even though, in terms of construction costs of flood protection works, this will be more expensive than the alternative of closing off the escape. This decision has been made because closing the escape will be difficult to justify politically and will inevitably increase the risk and frequency of flooding of the banana areas adjacent to the river, the cost of which is difficut to assess.

The project proposals are therefore as follows:-

(a) Rehabilitate the flood escape structure and the main road bridge across the channel, including the provision of bed and bank protection in the vicinity of the stuctures.

(b) Enlarge and extend the flood channel westwards through the northern part of the project area so that it can carry up to 100 m^3/s. This work includes associated embankments on either bank of the channel to contain the flow.

(c) Construct embankments along the northern and western boundaries of the project area to prevent the ingress of the flood waters resulting from use of the flood escape or from river flooding to the north.

(d) Enlarge the western drainage complex where necessary and excavate a pilot channel south-westwards from the southern end of the project area towards Dhesheeg Waamo. This will ensure the flood waters discharged through the escape can pass into the Dhesheeg Waamo lake.

These proposals will protect the project area from the flooding caused by 1 in 25 year return period flow in the river.

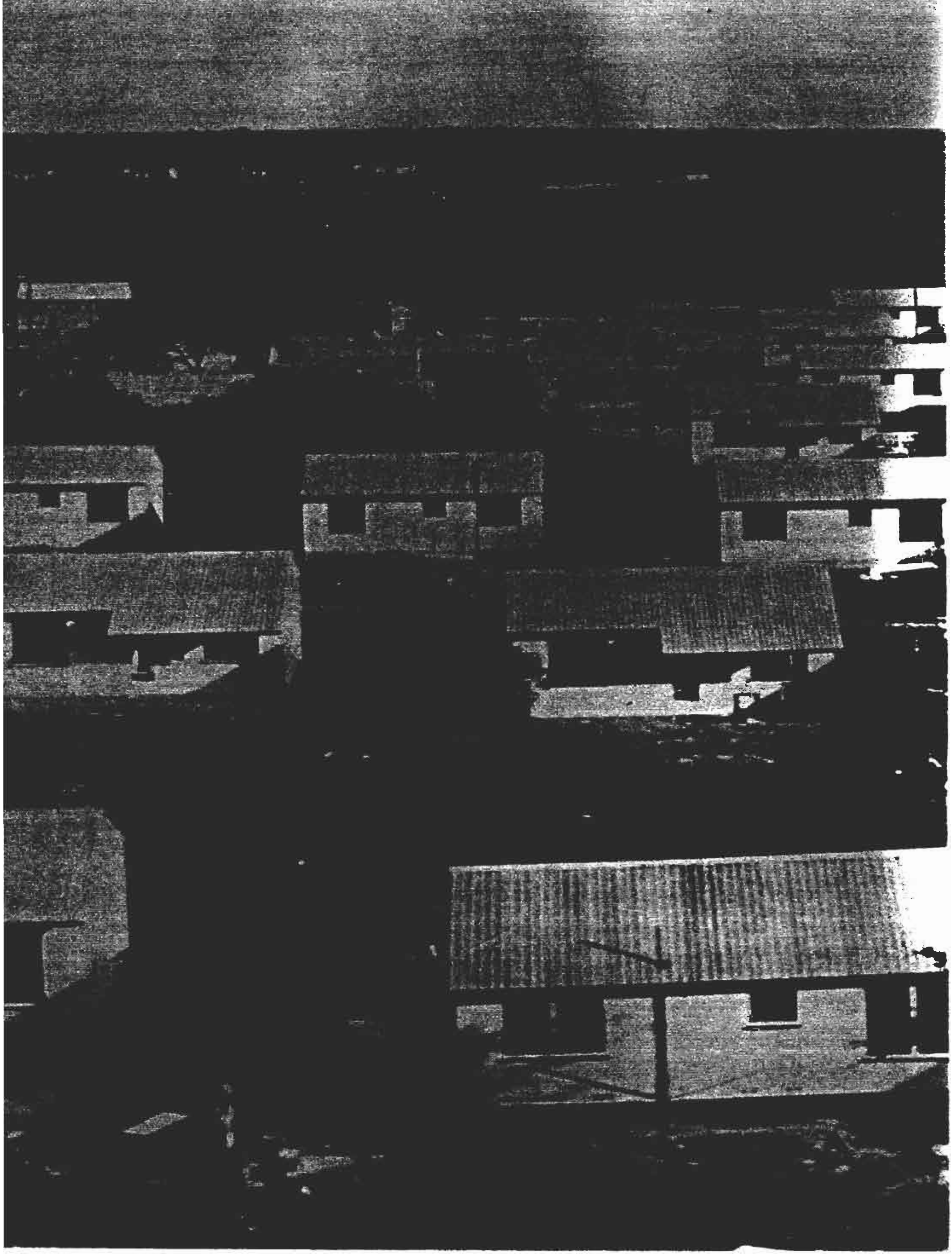
9.5.3 Influence of Bardheere Dam

The completion of Bardheere dam will make the project flood protection works generally redundant, as the maximum design discharge from the dam is 750 m^3/s which will give an estimated flow of about 650 m^3/s at Mogambo. This flow gives approximately bank full conditions at Mogambo and some spillage will occur in isolated places, but these will not affect the project. However, the earliest probable completion date for the Bardheere dam, assuming that funds are made available, is 1987. By this time the Mogambo project could be complete and have been operating at full implementation for two or three years.

An approximate risk analysis has therefore been carried out to investigate the economics of not providing any flood protection works for the Mogambo project on the basis that full protection will be given by Bardheere dam eight years after the start of construction. The results are presented in Annex 5 and it is clear that, in view of the likely cost of damage to the project from a 1 in 10 year flood, the risk of not providing flood protection is unacceptable.

Consquently, unless the construction of the Mogambo project is delayed until such time as the completion of Bardheere dam is imminent, the project proposals for flood protection as described in Section 9.5.2 should be implemented.

Infrastructural Planning 10



CHAPTER 10

INFRASTRUCTURAL PLANNING

10.1 The State Farm Concept

The specific advantages of the state farm as a development institution are that all agricultural activities (including the operation of the irrigation system) are centrally controlled and the workforce is disciplined, especially in the sense that it is paid to perform specific functions, under supervision, and is encouraged, by bonus schemes, to perform these functions at an above average efficiency rate. Motivation for the subordinate workforce is through relatively desirable community facilities, good basic wages and productivity. The disadvantages are that initiative is not encouraged, motivation is less powerful than would be the case with a smallholder scheme and individual involvement is limited without such features as are proposed below.

10.2 Village Organisation

It is proposed that the majority of the 1 600 people permanently employed on the farm be accommodated within the project area. Sixty of this total will be senior and junior executives, whose accommodation will be of a standard appropriate to their status as graduates. The remainder will be clerks, technicians, supervisors, foremen, skilled and unskilled labour. The project area will be divided into four more or less equal farms, each including some area of surface irrigation and some of overhead. Each of the four farms would have its own village and workforce, including a farm manager, a field agriculturalist, a mechanisation supervisor, an irrigation supervisor, technicians and foremen, its own mechanised equipment and its own irrigation system. The four farms would be under unified control from an administrative centre (project headquarters) which would have a working population of about 300, a headquarters farm (about 27 ha), a seed processing plant, a rice hullery and a central workshop.

It is further proposed that each village should be built upon one modular basis, with units of eight houses with a communal water yard constituting the basic module. There would be a number of these 'neighbourhood groups' to a ward, and each village would have four wards. Each ward would have space for simple shops, but the village centre would be provided with a community centre, a dispensary (or first aid post), a primary school and space for a mosque. Each farm village would have the support of a three man social, agricultural and livestock extension group. Under the advice and assistance of the community services officer, the wards would be encouraged to elect committees, with two representatives for the village production committee, a body with which the farm manager would discuss problems of production and other aspects. Every effort would be made to work with the district and regional authorities in such matters as community activities, health, education and production. A typical village layout and the project headquarters layout are shown in Figures 10.1 and 10.2, and the general project infrastructure is shown in Figure 10.3.

The proposed changeover to bananas on 1 200 ha of the levee soils following the availability of perennial flows regulated by Bardheere dam, will require an additional workforce of up to 1 500. All these workers could, if necessary, be accommodated within the project villages, but it is probable that a proportion will live in the existing villages which have a history of providing labour for banana plantations.

10.3 Project Headquarters

The project headquarters is the nerve-centre of the entire project. It is here that the majority of the senior staff are accommodated together with the project administrative offices, workshops, stores, vehicle parks, the grain driers and rice mill. There is also a village within the headquarters which will house workers who are not directly associated with one of the four farms.

The project headquarters has been located centrally to the project area, on the eastern boundary near to the main Gelib-Kismayo road. A surfaced all-weather road has been provided to connect the headquarters to the existing main road. This road continues as an earth road through the project area and links the four villages.

Associated with the project headquarters is a farm of 27 ha net (one surface irrigation field unit) which will be used for training, seed production and agricultural trials. A training centre office is located nearby which will be used for the education of the workforce in the necessary skills and techniques.

Roads within the project headquarters, other than the primary road, will generally be graded earth roads but some crushed coral roads will be required where traffic is heavy.

The inclusion of bananas in the cropping pattern will require some additional facilities at the project headquarters, particularly packing sheds. Sufficient space has been provided for such expansion.

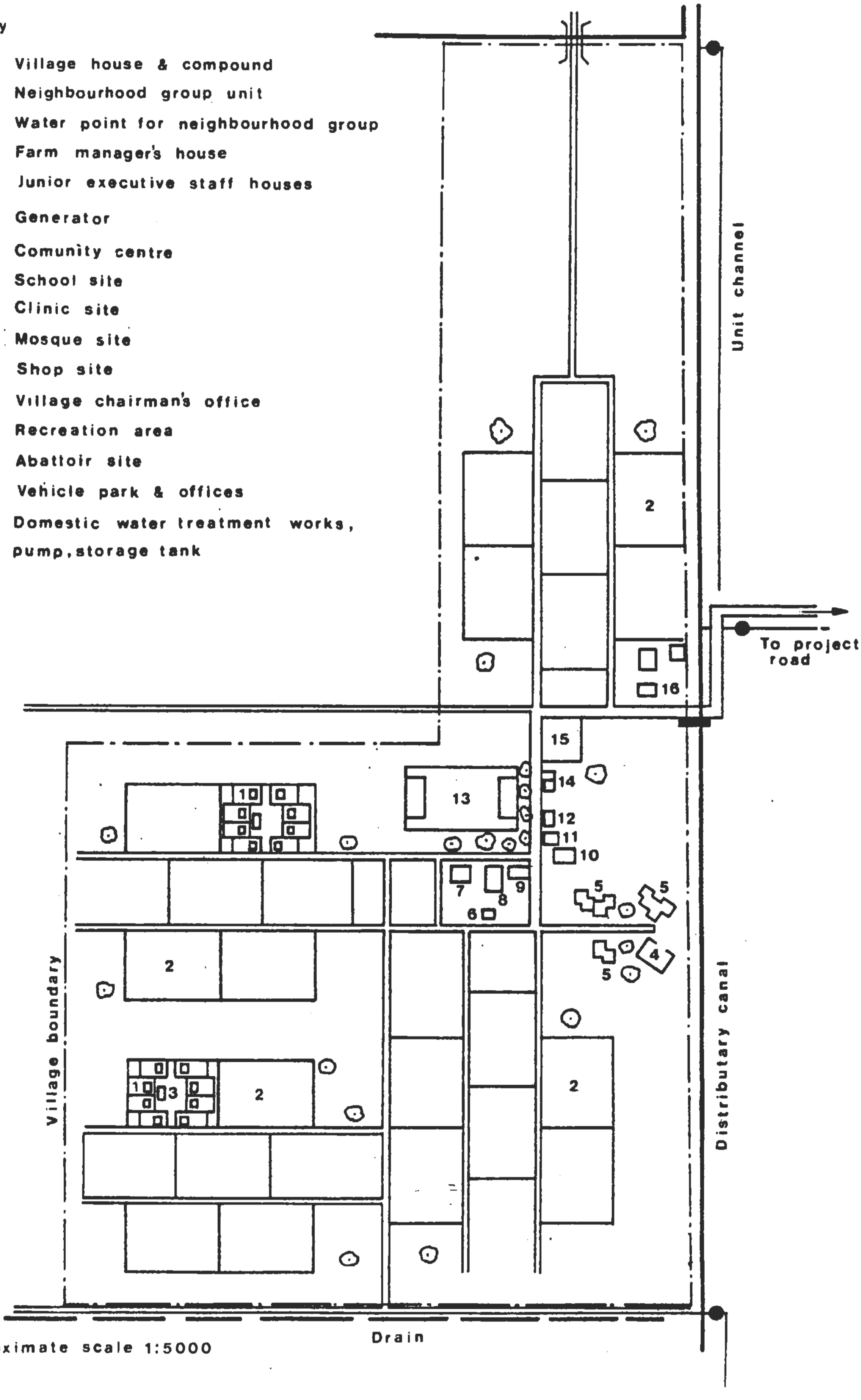
10.4 Power Supply

An integrated power supply for the whole project cannot be justified economically. However, electric power is essential for the project headquarters and is very desirable, albeit on a small scale, for the villages.

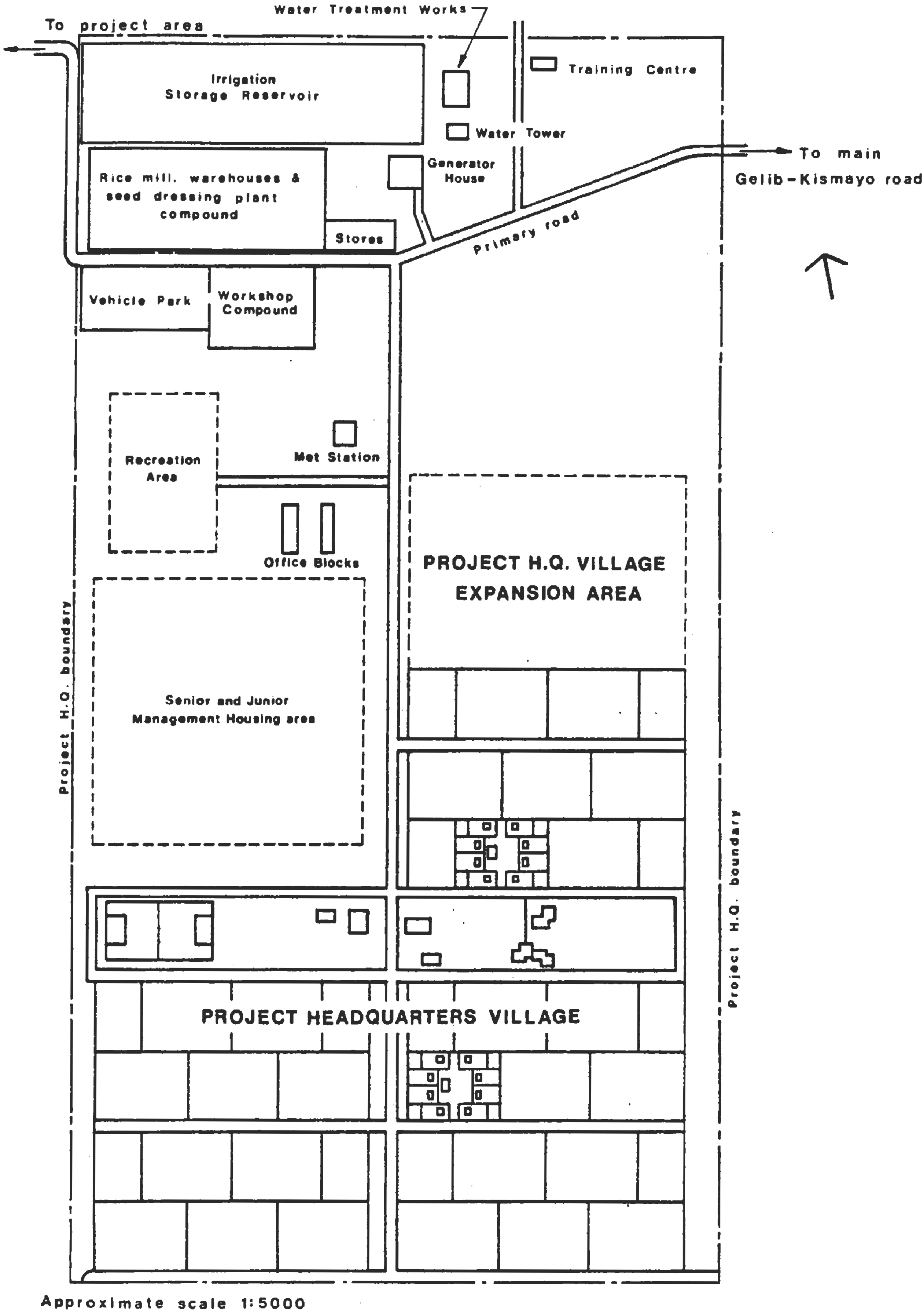
Electric power supply for the pump stations was also considered as this gives the advantage of easier control and permits the use of automatic on/off switching. However, since there are 15 pump stations (one main, nine sprinkler and five drainage) which are distributed across the project area, the economics of this could not be justified. All pump stations are therefore driven by direct drive diesel engines and small generating sets will be provided for electric lighting at night.

The power supply for the project headquarters will be provided by a generator house with two 400 kVA sets located on the northern edge of the headquarters, away from the houses and offices. By far the largest power demand comes from the grain driers and rice mill.

Typical project village layout

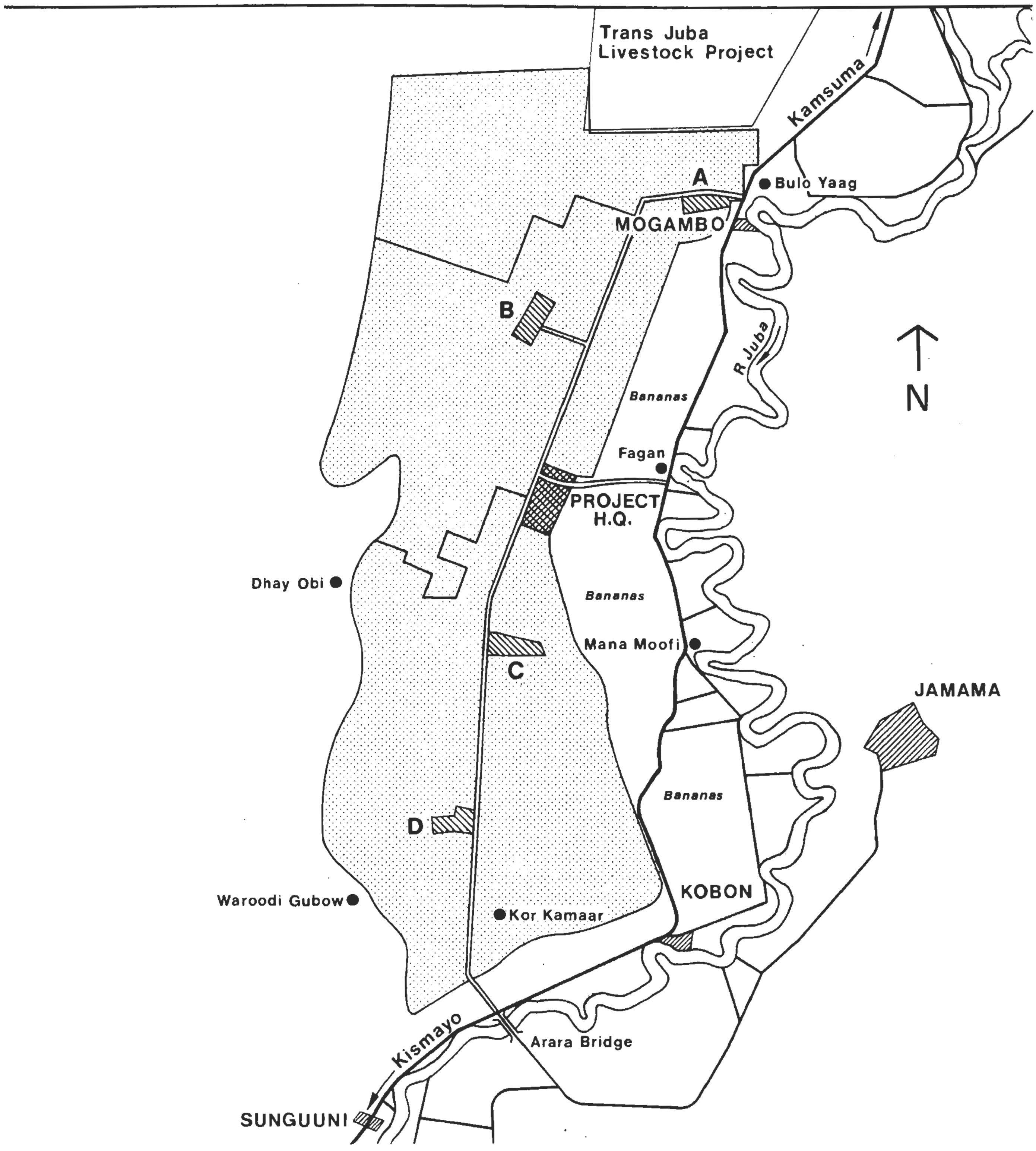


Approximate scale 1:5000


Water Treatment Works
To project area
Irrigation Storage Reservoir
Training Centre
Water Tower
Generator House
To main Gelib-Kismayo road
Rice mill, warehouses & seed dressing plant compound
Stores
Primary road
Vehicle Park
Workshop Compound
Recreation Area
Met Station
Office Blocks
PROJECT H.Q. VILLAGE EXPANSION AREA
Senior and Junior Management Housing area
Project H.Q. boundary
PROJECT HEADQUARTERS VILLAGE
Approximate scale 1:5000

Project infrastructure

10.3



For each village the power requirements are small, sufficient electricity being required only for the senior housing and the village school, clinic and community centre, and the pumped water supply. A suitable generating set housed in a small building will be provided. This will be located in the village near the community buildings.

10.5 Water Supply

The provision of an adequate, reliable and clean water supply for the villages and project headquarters is considered to be of paramount importance to the health and welfare of the project employees.

Two possible sources of supply have been considered:

(a) water pumped from canals

(b) groundwater.

Groundwater has the considerable advantage of not requiring treatment to make it potable. However, groundwater in the area tends to be rather saline and there is no guarantee that a well drilled at a village site will provide adequate quantities of suitable water.

The alternative of pumping water from canals involves the extra cost of treatment works which must be capable of producing a safe supply of water. There is an additional disadvantage with this system in that the canal system will be shut off during February to March. It will be necessary therefore to hold water in some of the storage reservoirs for release to the village water supplies through this 'closed' season.

Clearly the groundwater alternative is preferable and experience on the Trans-Juba livestock project (Chapter 4) and also the Juba Sugar project indicates that a suitable source probably exists. Trial boreholes will be required in the early stages of the project to establish this.

In the project headquarters, potable water will be piped into all senior staff houses, offices and workships. In the villages, water will be available at standpipes fitted with automatic valves. Each group of eight houses will have one standpipe.

10.6 Buildings

Buildings for the project will include, amongst others, houses, offices, community centres, workshops, stores and operators quarters. A complete list of buildings to be erected in the three year construction period is given in Table 10.1.

Village housing for the labourers and other employees will be constructed under a self-help scheme with materials and assistance provided by the contractor. It is intended that with this assistance and with guaranteed jobs at acceptable rates of pay, the labour required for the project will have sufficient incentive to construct their own houses in the plots designated. Similarly community facilities such as the mosque, shops and recreation facilities will be constructed by the villagers with assistance from the ministries or agencies concerned or from private enterprise in the case of shops. However, a school, a community centre and a small clinic will be constructed in each village under the main civil works contract. Full details of the types of buildings proposed for the project are given in Annex 5, Chapter 6.

It should be noted that the expansive clays of the project area present serious problems for building foundations. Other projects (for example Afgoi, Juba Sugar) are having to resort to expensive piled foundations to avoid rapid structural deterioration. For this reason the main buildings of the project headquarters have been sited as far as possible on lighter soils, but it will still be necessary to provide deep foundations to avoid problems.

As far as possible, village houses will be constructed from local materials obtained from clearance of the project area prior to construction. However, the extent of suitable material and the economics of sorting and stockpiling it will need further investigation. Other buildings will be constructed from the locally available coral stone except where this is inappropriate.

TABLE 10.1

Buildings Constructed in the Project

Building	Nr	Location	Approximate unit floor area (m^2)
House type AA	4	PHQ	230
House type A	9	PHQ & villages	200
House type B	46	PHQ & villages	100
Bungalow units	5	PHQ	60
General managers office block	1	PHQ	545
Deputy general managers office block	1	PHQ	545
Fuel station office	1	PHQ	30
Vehicle park offices	5	PHQ & villages	40
Mill compound office	1	PHQ	60
Workshop	1	PHQ	1 990
Warehouse	1	PHQ	1 080
Security unit	1	PHQ	12
Buildings for grain drier, grain storage and rice mill	1	PHQ	5 500
Training centre	1	PHQ	200
Dispensary	5	PHQ & villages	30
School	5	PHQ & villages	250
Operators' quarters	17	Villages	40

10.7 Roads and Services

Roads in the project area have been designed to permit access to all parts of the project and, in particular, to link all farm project villages to the project headquarters and to the main Gelib-Kismayo road. Only the main link road (primary road) connecting the project headquarters to the existing main road will be bitumen surfaced, so as to ensure all-weather access in and out of the headquarters. All other roads will be of graded earth except for some coral surface road within the project headquarters and the villages themselves. Earth roads will require regular maintenance and, more importantly, a restriction on their use in very wet conditions to avoid deep rutting. Generally it will not be necessary to gain access into the farms immediately after heavy rain but clearly some transport will have to move at such times. It will be up to the farm managers to enforce strict control over the use of this transport so that only essential traffic movement is permitted on wet roads.

Power and water supplies to the project have already been discussed. The disposal of sewage effluent will have to be on a small scale basis since a centralised system would be too expensive. For senior staff housing and offices, workshops and communal facilities, septic tanks are proposed. These will require careful positioning to avoid, where possible, the impermeable clay soils which would render them ineffective.

For the village housing, communal earth closets are proposed. If these are dug deeply and have an appropriate simple screen they can be extremely effective and not offensive. Some effort will have to be made to educate the people in their use but if these are sensibly sited at frequent intervals within the villages the advantages will soon become clear. The people of the villages should be actively discouraged from indiscriminate use of canals, drains and public areas which would otherwise rapidly become health hazards.

10.8 Health

Maintaining the good health of the farm workers will benefit not only the workers themselves but will also increase the profitability of the farm by increasing the output of the workforce. It will also help to attract workers to the project. Ultimately the whole region would benefit.

Disease can be attacked from two fronts: prevention and cure. Often the former is cheaper, more effective and, from the point of view of those affected, preferable. Furthermore, there are diseases for which there either is no cure or for which the cure is too expensive to justify its use on a large scale.

For Mogambo therefore the emphasis is on prevention, particularly through education. Nevertheless the following points in the planning of the project have been devised to reduce the occurrence of disease:-

(a) provision of a guaranteed supply of potable water

(b) provision of simple but effective toilet facilities

(c) provision of clinics

(d) establishment of a community services department

(e) the avoidance of canals and drains within villages.

11 Organisation and Management

CHAPTER 11

ORGANISATION AND MANAGEMENT

11.1 Introduction

There is no doubt that the success of the Mogambo project will depend to a large extent on an effective management structure which must be established at the very start of the project. There is no substitute for good management and previous experience on state farms has shown that failure often results from lack of experience in this field. In Somalia there is a shortage of people with the relevant experience and, with the proposed rate of development of agricultural projects in the country, this situation is unlikely to improve in the near future.

It is therefore proposed that, for the implementation stage of the Mogambo project, a number of experienced expatriate personnel are engaged to organise the early development of the farm. These expatriates will be replaced subsequently by Somali graduates who will have held positions of responsibility on the farm for a number of years. This aspect of the project is discussed in more detail in Chapter 13.

11.2 Project Administration

The proposed management structure and farm organisation are illustrated in Figures 11.1 and 11.2. The underlying concept is one of direct line control from the general manager down.

The Mogambo board will be made up of representatives from the three ministries: Agriculture; Livestock, Forestry and Range; Industry; plus representatives from the State Planning Commission and the proposed Juba Valley Development Authority. The general manager of the project will be the chairman of the board. The deputy general manager (operations) will be in charge of all farm operations, operating through his four farm managers and specialists in agronomy and irrigation.

Day to day running of the farms will be the responsibility of the farm managers, who will be assisted by supervisors for irrigation, mechanisation and agricultural operations. Operation of the irrigation system within each farm will be under the control of the farm manager in conjunction with the irrigation engineer. The operation and maintenance of the main canal and irrigation and drainage pump stations will be the responsibility of the irrigation engineer. The farm managers will also direct the use and day to day maintenance of their own agricultural machinery but servicing, repair and overhauls will be carried out at the project headquarters workshop, supervised by a workshop manager.

Training of staff on the farm will be supervised by a training manager under the general control of the administrative manager. The training manager will have an officer located in each farm so that training operations can be incorporated in the daily farm routine and there will be a training centre at the project headquarters for more formal training and practical demonstrations.

The administrative manager will also be responsible for personnel and community services.

The chief accountant will control the financial side of the farm management and his responsibilities will include budget, wages and stores control.

11.3 Operation and Maintenance of the Irrigation and Drainage System

The irrigation engineer will be in overall charge of operation and maintenance but much of the routine work will be carried out under the supervision of each farm manager on his farm.

A rigid hierarchy of management for the irrigation system is proposed so that wastage of water is reduced to an absolute minimum. The irrigation engineer will supervise the operation and maintenance of the main pump station, the main canal and settling basin, the sprinkler pump stations, the drainage pump stations and the storage reservoirs. He will have a team of operators and maintenance staff with appropriate machinery and vehicles who will ensure that the required amounts of water are in the right places at the right times.

In the farms the distributary canals will be operated by ditch riders under the direction of irrigation supervisors working for the farm managers in conjunction with the irrigation engineer. Field irrigation will be organised by block supervisors in each farm, working through foremen and irrigation labourers.

Maintenance of canals and drains within the farms will be organised on a day to day basis by the operational staff when they are not fully occupied in operation. Much of this work, including minor bank repairs to field channels and weed clearance, can be done by hand. When irrigation requirements are low and in the 'closed season' (February and March) maintenance can be carried out on a large scale using the irrigation labour and plant machinery provided.

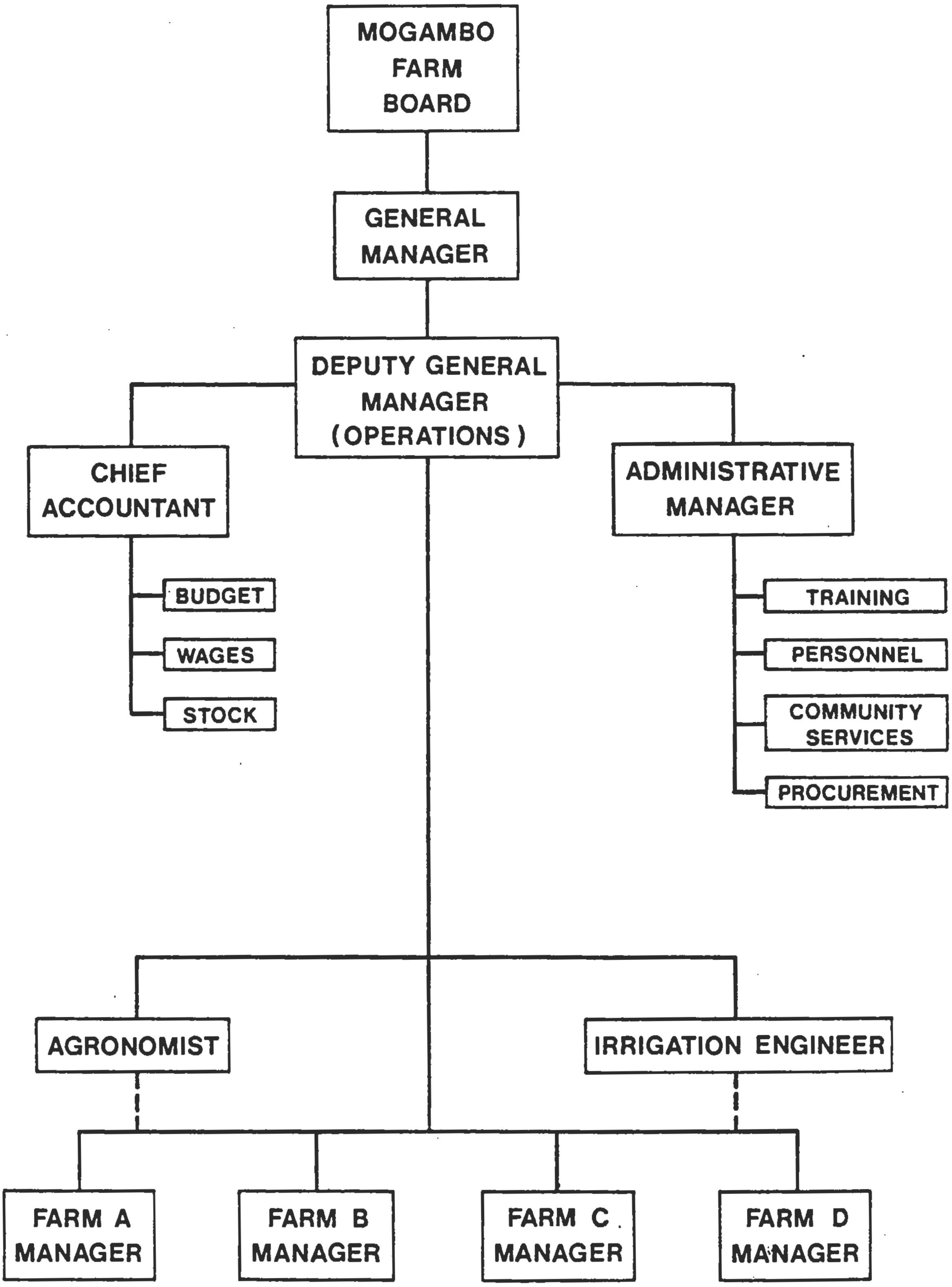
A list of the operation and maintenance plant proposed for the project is given in Table 11.1. Full details of the operation and maintenance proposals are given in Annex 5, Chapter 7.

11.4 Research

Clearly the proposals for cropping and agricultural operations will be modified and improved continuously throughout the life of the project. This will come about as a result of experience gained on the farms particularly with regard to such aspects as weed and pest control, tillage operations and harvesting requirements. Other aspects, such as the development of superior crop varieties, can be researched on the project headquarters farm which will also be used for seed multiplication. The project proposals also include a 100 ha trial area for machine harvested cotton so that the possibility of introducing this system can be thoroughly investigated. This system need not be pursued if the labour required for manual harvesting of cotton proves to be readily available.

The results of research carried out on the project will be of use to other on-going and proposed projects and, similarly, research results from the projects and from the Afgoi research station (CARS) will be of value to the Mogambo project.

Organisation of Mogambo Farm: Operational stage



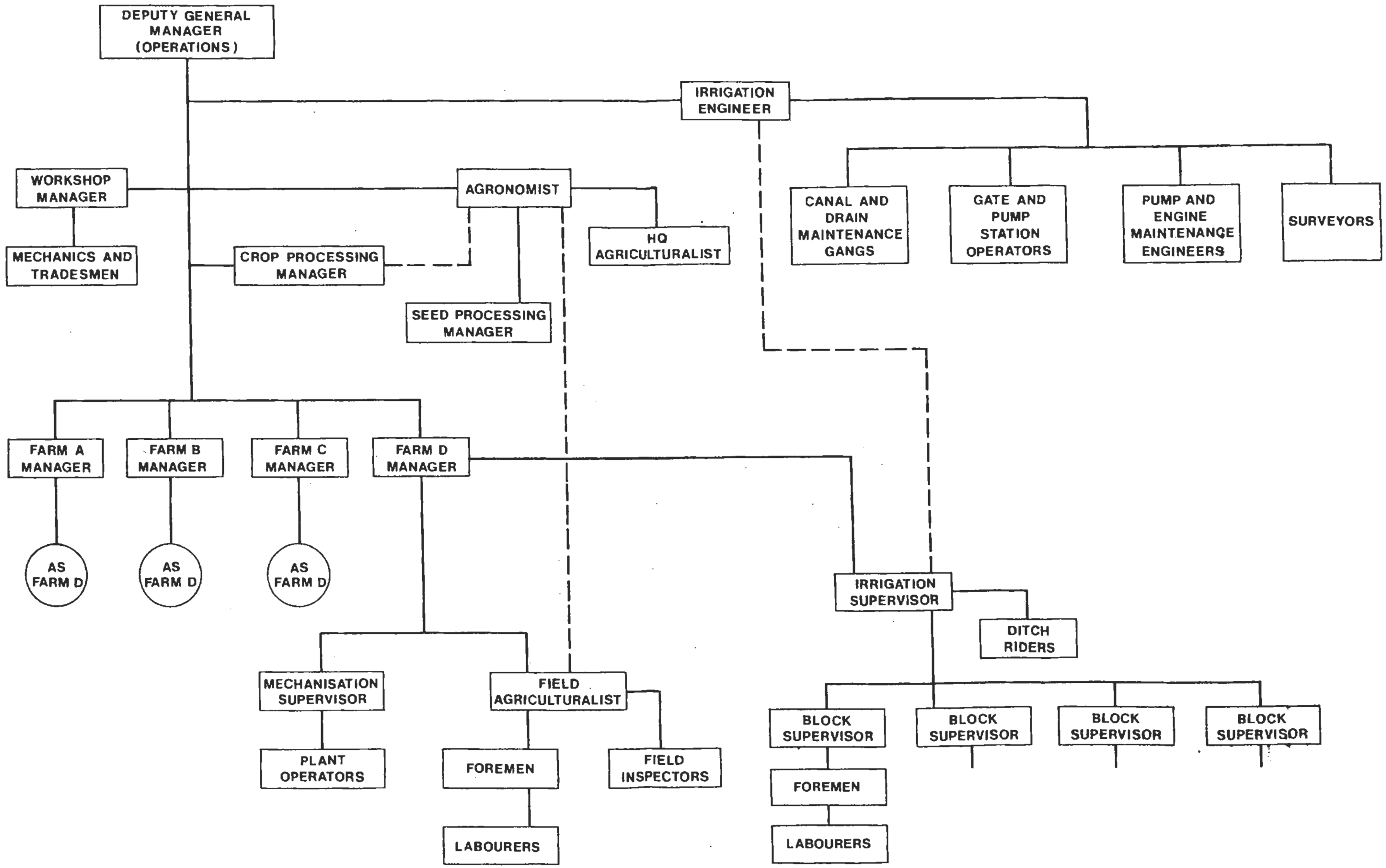

DEPUTY GENERAL MANAGER (OPERATIONS)
IRRIGATION ENGINEER
CANAL AND DRAIN MAINTENANCE GANGS
GATE AND PUMP STATION OPERATORS
PUMP AND ENGINE MAINTENANCE ENGINEERS
SURVEYORS
WORKSHOP MANAGER
MECHANICS AND TRADESMEN
AGRONOMIST
HQ AGRICULTURALIST
CROP PROCESSING MANAGER
SEED PROCESSING MANAGER
FARM A MANAGER
FARM B MANAGER
FARM C MANAGER
FARM D MANAGER
AS FARM D
AS FARM D
AS FARM D
MECHANISATION SUPERVISOR
PLANT OPERATORS
FIELD AGRICULTURALIST
FOREMEN
LABOURERS
FIELD INSPECTORS
IRRIGATION SUPERVISOR
DITCH RIDERS
BLOCK SUPERVISOR
BLOCK SUPERVISOR
BLOCK SUPERVISOR
BLOCK SUPERVISOR
FOREMEN
LABOURERS

TABLE 11.1

Vehicles and Machinery for Operation and Maintenance

Item	Use	Nr
Bicycles	Foreman irrigators	40
Motorcycles	Block supervisors	16
Motorcycles	Ditch riders	13
4WD station wagon	Irrigation supervisors	4
4WD station wagon	Irrigation specialist	1
4WD pick up	Maintenance crews	4
Truck	Transport, etc.	4
Truck (tipper)	Transport, etc.	4
Tractor and trailer	General	8
Hydraulic excavator	Canal plus drain maintenance	2
Dragline	Canal plus drain maintenance	1
Floating grab dredger	Settling basins + reservoirs	1
Split bottom barge	Reservoirs	1
Grader	General	2
Bulldozer (D6)	General	2
Low loader	General	1
Water bowser	General	1
Concrete mixer		2
Vibrators		2
Compressor with tools		1
Mobile workshop		1
Water pump		3
Flail mowers on hydraulic arms		2
Circular saw		1

The supervision and control of research operations at Mogambo will be the responsibility of the agronomist.

In view of the proposed changeover to bananas on up to 1 200 ha of levee soils following the implementation of Bardheere dam, it is desirable that some small areas of bananas are cultivated in the early stages of the project. In this way it will be possible to experiment with the overhead irrigation proposed for this crop so that any modifications or refinements can be incorporated before the changeover takes place. It would also be possible to discover which areas of the project are most suited to banana cultivation, or indeed for any of the crops proposed for the levee soils, so that the final cropping pattern can be based on known land suitability.

11.5 Staff Requirements

A complete list of the staff required for the project, including the expatriate staff proposed, is given in Chapter 13 of this volume (Table 13.1). The staff total is approximately 1 600 of which 1 000 are unskilled labourers. A total of 47 Somali graduates will be required by year 7 of the implementation programme although some of the posts could be filled by people with lesser qualifications. The remaining workers are made up of technicians (330), supervisors (70), clerks and secretaries (40) and skilled labourers (112).

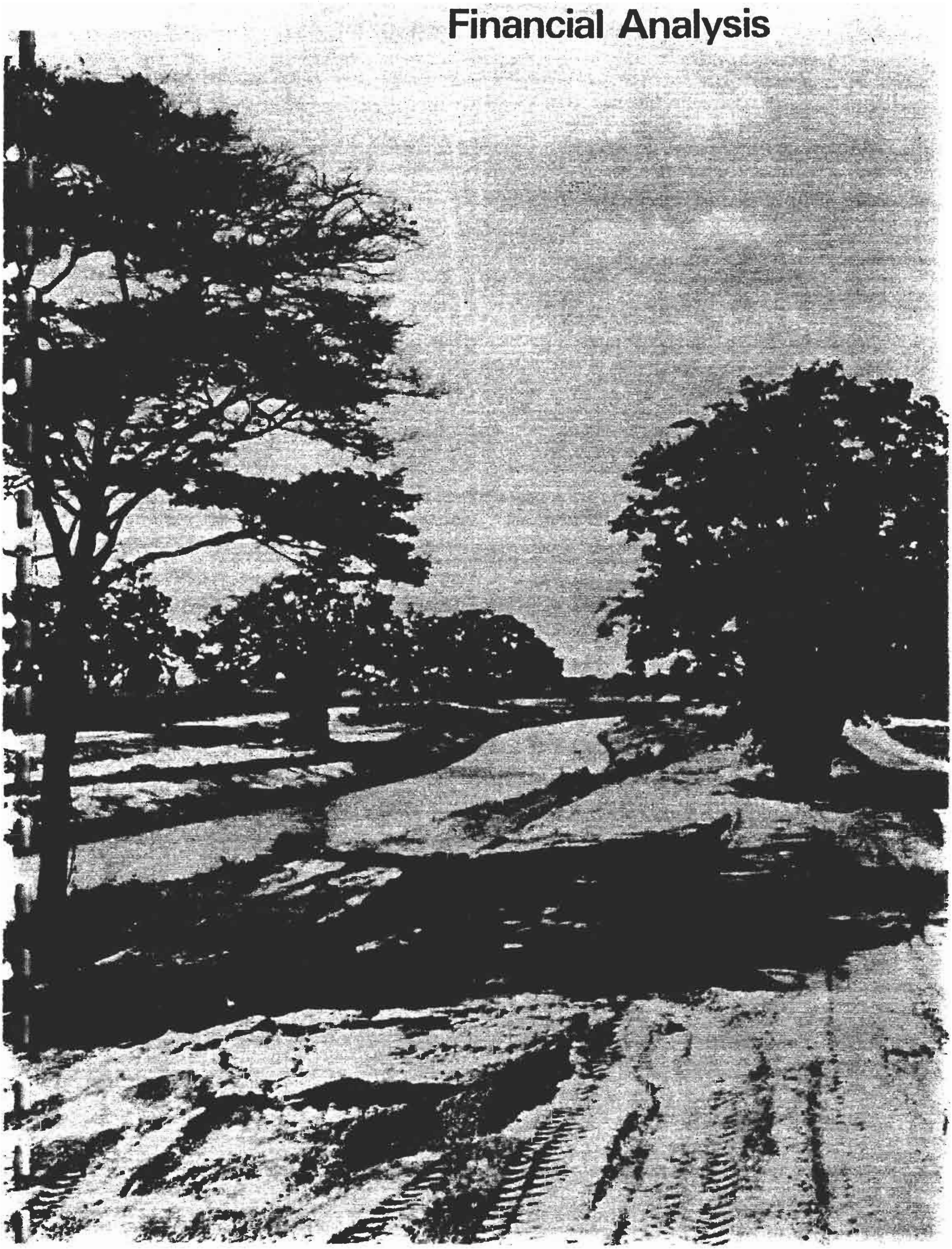
Positions filled by expatriate staff (10) in the first years of the project will subsequently be occupied by the best of the Somali graduates employed on the farm. These graduates will have occupied positions under the direction of the expatriate personnel and will therefore have had a minimum of two years experience of relevant work before taking on full responsibility. This system is preferred to that of appointing counterparts to the expatriate posts.

The proposed changeover to bananas, starting at the earliest in year 7 of the project, will require an increased workforce. As many as 1 500 more labourers will be required, depending on the final area of bananas cultivated. This increased workforce is not shown in Table 13.1 but has been included in the economic and financial analyses presented in Chapter 12 of this volume and in Annex 7.

PART III

ECONOMIC AND FINANCIAL ANALYSIS

Economic and Financial Analysis 12



CHAPTER 12

ECONOMIC AND FINANCIAL ANALYSIS

12.1 Bases for Analysis

The project life has been taken at 30 years, the expected life of the most durable component, the civil engineering works. Salvage values have not been included for plant and machinery since there is a shortage of potential buyers and the machines would probably be retained as a source of spare parts.

The labour rates assumed have been based on a synthesis of current payments by Government, by the Juba Sugar project and by other local employers. The one exception is unskilled labour. The current rate at the Juba Sugar project is SoSh 8/d but all employers report great difficulty in finding workers at this price. It appears that, at least in the Juba valley, potential labour considers the wage too low to be worth working for; this independence of attitude may be supported by remittances from family members working overseas. In view of the expected growth of employment opportunities in the Juba Valley, a financial wage rate of SoSh 12/d has been assumed, plus the attractions for the permanent labour force of housing, infrastructural services and benefits, and an irrigated 'garden' plot of land. However, unemployment, particularly seasonal, does exist, so a shadow wage rate of SoSh 8/d has been used for the economic analysis.

The Somali shilling has been linked to the US dollar since 1972 at a rate of SoSh 6.295 = US $ 1.00. However, most authorities regard this as an over-valuation of the shilling.

In neighbouring Arabian countries, which are the only other locations where the Somali shilling is traded, exchange rates as low as SoSh 15 to the US dollar are quoted. A sensitivity analysis has been carried out using a shadow value for foreign exchange of SoSh 9.5 per US dollar which is the rate assumed by IBRD. It will be seen subsequently that this has a significant effect on the economic performance of the project.

Taxes and duties have been removed from financial prices when assessing economic costs. Some large-scale agricultural developments are exempt from all duties, but the exemption is not a right and cannot be assumed as a matter of course.

The original TAMS/FINTECS report included a substantial feedlot component. The results of the new physical surveys undertaken in the present study have led to a change in the cropping pattern with the result that of all the project output only maize stover is of direct use to a feedlot. Any proposed feedlot therefore becomes essentially independent of the Mogambo project, and a model has been specified and analysed separately in Annex 4. The results of this analysis showed the feedlot to be not viable either economically or financially and it has been omitted from the following analyses.

The Government has expressed a firm determination to expedite the construction of the dam at Bardheere. The major effect of this dam on the Mogambo project would be to allow perennial crops to be grown, of which bananas is the only crop recommended on agronomic grounds. In those analyses which consider the effect of

Bardheere dam, controlled water has been assumed to become available in project year 8. No water costs, either present or future, have been charged to the project owing to the impossibility of estimating either the costs of providing the water or the final number of extent of downstream users.

Flood protection works, which will be necessary if the project is implemented before Bardheere dam is constructed, will also benefit growers downstream of Mogambo. Accordingly only 40% of flood protection costs have been charged to the Mogambo project.

12.2 Output Prices and Crop Net Margins

Government controlled prices paid for crops in Somalia have not risen since 1977. Accordingly the financial crop prices assumed for analysis were taken as the current 1979 farmgate prices inflated by the forecast percentage rise in constant currency terms for those commodities on the world markets by 1985. The economic prices were the 1985 constant currency forecast world market prices, converted back to farmgate prices by adjustments for transport, handling and processing where appropriate. Table 12.1 shows the price levels used.

TABLE 12.1

Current and Forecast Crop Prices (SoSh/quintal)

Crop	1979 price	Forecast price Financial	Forecast price Economic
Rice (indica) - milled	350	465	346
Maize	75	97	120
Sesame	240	267	335
Cotton - grade 1	240	286	316
Bananas - export	56.5	67.5	83.2

Six crops, paddy rice, upland rice, maize, cotton, sesame and bananas, were selected on agronomic grounds for inclusion in the project. Net margins were drawn up for these crops in order to assess the comparative profitability of each. In this report, net margins reflect gross output less direct inputs, machinery costs (including operators and depreciation), unskilled labour and processing costs where applicable. This approach has been taken in order to attribute as many costs to each crop as possible, except for unattributable overheads, as opposed to the more traditional gross margins which obscure differing crop requirements for machinery, labour and processing. Multiplying the crop net margin by the hectares cropped will not necessarily correspond to the costs or the cash flow since some items such as machinery and labour are used year-round on the project but only part of their time can be attributed to a crop, the rest being an overhead cost. Table 12.2 lists the net margins.

TABLE 12.2

Crop Net Margins (SoSh/ha)

Crop	Financial	Economic
Paddy rice	9 482	6 409
Upland rice	7 917	5 257
Surface maize	1 238	2 368
Sprinkler maize	1 330	2 435
Sesame	47	811
Cotton - hand harvested	3 245	4 550
Cotton - machine harvested	1 880	2 753
Bananas - average over 6 years	4 464	9 631

Paddy rice is the most profitable annual crop in economic terms followed in descending order by upland rice, cotton and maize. Sesame shows low returns due to the poor incremental yield resulting from irrigation. Cotton occupies the land area for the whole year, but rice and maize can be grown in either or both seasons. If water is available for perennial cropping, bananas show similar returns to a paddy rice-maize combination.

In financial terms, the ranking of the annual crops stays the same, although rice becomes more profitable whereas the other crops become less so. Bananas are less attractive, although still more profitable than cotton on the levee soils.

As a result of the low net margin and high labour requirements for harvesting, it was decided to omit sesame from the final cropping pattern.

12.3 The Base Case

The first model for the project, referred to as the 'base case', was designed on the assumption that the implementation of Bardheere dam could not be guaranteed. Perennial crops were therefore excluded.

A clear distinction was drawn between cropping patterns on the basin soils and on the levees, and within this framework the area of the most profitable crops was maximised.

On the basin clay soils, 100% (3 300 ha) of paddy rice is proposed for the gu season, followed by 70% (2 300 ha) of maize in the der season. Double cropping of rice was considered but in view of the complexity of management, the possibility of toxicity build-up and problems with aquatic weeds, this was rejected.

On the levee soils, upland rice followed by maize is the most profitable combination, but was restricted to 1 000 ha, one-third of the area, for rotational reasons. Cotton is the next most profitable crop but was restricted to 1 000 ha because of the high seasonal labour demand. An area of 100 ha of machine picked cotton was also included; this technique is less profitable than hand-picking cotton but, if the labour shortage worsens and the comparatively new machines perform satisfactorily, it may be necessary to expand its use in future.

The remaining 1 000 ha was to be planted to maize in the der season.

Following a survey on site, the value of present production was estimated by assuming that 1 000 ha would be cropped with maize in the gu season, followed by 600 ha of sesame in the der. Yields were taken at 5 and 2.5 quintals/ha respectively. The use of purchased inputs was so low as to be negligble. Livestock production would not be affected by the implementation of the project, the stock would simply be relocated.

Table 12.3 shows the agricultural implementation schedule for the base case.

TABLE 12.3

Base Case Agricultural Implementation Schedule (ha net)

Crop	Year 2	3	4	5 onwards
Paddy rice	243	1 107	2 538	3 321
Upland rice	-	-	724	998
Surface maize	648	1 620	1 620	2 295
Sprinkler maize	-	-	1 173	2 006
Cotton - hand harvested	-	449	838	1 003
Cotton - machine harvested	-	-	100	100

The capital and operating costs were then calculated as detailed in Annex 5 and Annex 7. Because of the capital intensive nature of the project it was decided to include original purchase and replacement costs for capital equipment rather than applying depreciation charges, which give a false impression of borrowing requirements and slightly inflate the internal rate of return of a project.

Table 12.4 lists the value of incremental production, capital and replacement costs and operating costs of the base case using economic values.

A range of sensitivity tests were undertaken, shown in Table 12.5.

TABLE 12.4

Summary of Base Case Costs and Returns (SoSh '000)

Year	Value of incremental production	Capital and replacement costs	Operating costs
1	(364)	63 113	2 177
2	2 677	132 182	9 250
3	12 846	106 208	19 088
4	33 207	14 937	34 235
5	51 269	7 685	40 535
6	59 964	1 296	38 554
7	66 286	6 154	37 587
8	68 732	8 722	37 587
9	68 732	8 738	37 587
10	68 732	11 977	37 587
11	68 732	9 495	37 587
12	68 732	20 230	37 587
13	68 732	13 379	37 587
14	68 732	8 466	37 587
15	68 732	6 220	37 587
16	68 732	5 686	37 587
17	68 732	16 494	37 587
18	68 732	12 962	37 587
19	68 732	9 466	37 587
20	68 732	6 817	37 587
21	68 732	4 803	37 587
22	68 732	19 882	37 587
23	68 732	16 261	37 587
24	68 732	9 638	37 587
25	68 732	7 818	37 587
26	68 732	6 943	37 587
27	68 732	10 341	37 587
28	68 732	12 037	37 587
29	68 732	6 678	37 587
30	68 732	5 265	37 587

TABLE 12.5

Results of Sensitivity Tests of Base Case

	Model	Internal rate of return (%)
1.	Economic values	3.05
2.	Financial values	3.27
3.	Foreign exchange costs and revenues	10.39
4.	As 1 but foreign exchange upvalued by 50%	5.16
5.	As 1 but capital costs increased by 20%	1.30
6.	As 1 but operating costs increased by 20%	0
7.	As 1 but output 20% less	-ve
8.	As 1 but output delayed by 2 years	0.88
9.	As 1 but capital costs 10% less	5.80
10.	As 1 but operating costs 10% less	5.99
11.	As 1 but output 20% greater	7.44
12.	As 1 but output achieved 1 year early	4.85
13.	As 1 but expatriate costs excluded	3.73
14.	As 1 but capital and operating costs + 10% and output delayed 1 year	-0.6

The internal rate of return (IRR) of the base case at economic prices is very low at 3.05%. This is mainly due to the high initial costs of the project. Table 12.4 shows that at full development incremental returns exceed total costs by some SoSh 20 million per year, but the capital costs of the project in the first three years exceed SoSh 300 million, to the breakeven point is delayed to year 20.

The financial rate of return is very similar to the economic since forecast increases in crop prices are offset by the inclusion of taxes and duties and the removal of the shadow price for labour.

The IRR is not particularly sensitive to changes in capital or operating costs. A 20% alteration changes the IRR by 2%; changes in output have a slightly greater effect. Although there is a moderately high requirement for expatriates in the early years, removing the costs of their salaries has little effect on profitability.

The most significant result of the analyses is the relationship between foreign exchange earnings and costs. Discounting only these two streams gives an IRR of 10.4%, so when foreign exchange is given its true open market value of SoSh 9.5 per US dollar, the IRR rises to 5.2%.

Even so, the project was not considered profitable enough in this form to put forward for funding and various alternative cases were constructed and analysed.

12.4 Comparison of Alternative Cases

Five alternatives were considered in order to raise the profitability of the project.

Case 2 considered only the basin soils which were cheaper to develop and will grow more valuable crops than the levee soils. The cropping pattern (as base case) would not be altered when Bardheere dam is constructed.

Case 3 used the same model but assumed Bardheere was already in operation so that flood protection works were not required.

Case 4 delayed implementation of the whole project until Bardheere was commissioned, then developed the whole area but with 1 200 ha of bananas replacing maize on the levee soils.

Case 5 used the same full development model as case 4, but assumed the basin soils were developed before, and the levee soils after, Bardheere dam becomes operational.

Case 6 used the same assumption as the base case, that the whole area would be developed before Bardheere dam, but that bananas would replace maize on 1 200 ha when perennial water is available.

Table 12.6 summarises the results. Only economic analyses were undertaken since little difference was expected between the financial and economic results.

Cases 2 and 3, in which only the basin soils are developed, show little improvement in IRR since the increased per hectare returns are offset by loss of economies of scale, and a more dispersed farm layout.

Case 4 shows slightly the highest IRR but would involve delaying the whole project until after Bardheere dam was constructed and is therefore not recommended.

Case 5 shows little improvement on the base case and is not recommended. Case 6 has the second highest rate of return and allows the whole area to be developed at the earliest opportunity. Case 6 is therefore recommended for final submission.

12.5 Further Analysis of Recommended Option

Table 12.7 summarises the 30 year economic cash flow of case 6.

The internal economic rate of return is 5.38%. The inclusion of bananas in the rotation worsens the internal financial rate of return, which drops to 4.09% owing to higher demands for unskilled labour and poorer prospects for a future financial price rise.

Assuming no loan repayments or interest charges, the economic break-even point occurs in year 18. Taking the cost of capital in Somalia as the 6% offered by the Somali Development Bank, the benefit-cost ratio becomes 0.974. The net present worth of the project after 30 years at 6% interest is negative at minus SoSh 23 279 000.

The net non-discounted surplus of foreign exchange earnings over foreign exchange costs after 30 years comes to SoSh 1 387 million, or US $ 220 million.

The results of a range of sensitivity analyses are shown in Table 12.8. As with the base case, the project is more sensitive to changes in output than to changes in either capital or operating costs. Advancing or retarding implementation has little effect, nor has a change in the date when Bardheere dam becomes operational.

TABLE 12.6

Summary of Alternative Cases (Economic Values)

Case	Cropping pattern (ha)								Flood protection	IRR (%)
	Before Bardheere				After Bardheere					
	Basin soils		Levee soils		Basin soils		Levee soils			
Base	Paddy rice	3 321	Upland rice	998						
	Maize	2 295	Maize	2 006	no change				Yes	3.05
			Cotton	1 103						
2	Paddy rice	3 600	-		no change				Yes	4.07
	Maize	2 500	-							
3	-		-		Paddy rice	3 600	-		No	4.20
					Maize	2 500	-			
4	-		-		Paddy rice	3 321	Upland rice	974	No	6.16
					Maize	2 295	Maize	974		
							Cotton	962		
							Bananas	1 173		
5	Paddy rice	3 321	-		Paddy rice	3 321	Upland rice	855	Yes	3.94
	Maize	2 295	-		Maize	2 295	Maize	855		
							Cotton	1 081		
							Bananas	1 173		
6	Paddy rice	3 321	Upland rice	998	Paddy rice	3 321	Upland rice	856	Yes	5.38
	Maize	2 295	Maize	2 006	Maize	2 376	Maize	856		
			Cotton	1 103			Cotton	1 080		
			Bananas	-			Bananas	1 173		

Note: Banana crop is grown in one location continuously. Other crops are rotated each year and therefore the cropped areas will vary slightly, except that paddy rice occupies 100% of the basin soils every year.

TABLE 12.7

Economic Cash Flows - Case 6 (SoSh '000)

Year	Value of incremental production	Capital and replacement costs	Operating costs
1	(364)	63 681	2 177
2	2 677	132 981	9 227
3	12 562	107 454	18 992
4	32 679	16 636	34 420
5	50 493	8 849	40 516
6	59 642	1 786	38 694
7	63 631	7 201	41 684
8	72 919	9 609	47 003
9	88 842	9 568	45 023
10	88 517	13 033	45 023
11	87 728	10 315	45 023
12	87 728	21 310	45 023
13	87 728	14 319	45 023
14	87 728	9 429	45 023
15	87 728	6 956	45 023
16	87 728	5 942	45 023
17	87 728	17 622	45 023
18	87 728	14 420	45 023
19	87 728	10 795	45 023
20	87 728	7 917	45 023
21	87 728	4 964	45 023
22	87 728	17 362	45 023
23	87 728	15 505	45 023
24	87 728	8 706	45 023
25	87 728	9 430	45 023
26	87 728	6 621	45 023
27	87 728	8 136	45 023
28	87 728	9 669	45 023
29	87 728	7 253	45 023
30	87 728	6 466	45 023

The relationship between foreign exchange earned and spent is even more encouraging than in the base case, when bananas are included in the rotation. Accepting the view that the Somali shilling is overvalued by 50% gives an internal rate of return of 9.1% when foreign exchange is valued correctly.

The rates of return generated by the proposed project are not high, owing to the very high initial costs of land levelling, irrigation and drainage works and infrastructural construction. However, the project does have positive financial benefits as well as economic and would still be viable if Bardheere dam were delayed or cancelled. In addition, no attempt has been made to quantify such benefits as increased non-project employment, better nutritional standards, wider extension efforts, dissemination of new technologies and increased numbers of skilled workers.

TABLE 12.8

Results of Sensitivity Tests on Case 6

	Model	Internal rate of return (%)
1.	Economic values	5.38
2.	Financial values	4.09
3.	Relationships of foreign exchange flows	16.47
4.	As 1 but foreign exchange devalued by 50%	9.09
5.	As 1 but capital costs increased by 20%	3.88
6.	As 1 but operating costs increased by 20%	2.93
7.	As 1 but output decreased by 20%	0.31
8.	As 1 but output delayed 2 years	2.98
9.	As 1 but capital costs decreased by 20%	7.78
10.	As 1 but operating costs decreased by 20%	8.09
11.	As 1 but output increased by 20%	9.63
12.	As 1 but output achieved 1 year early	7.51
13.	As 1 but Bardheere dam 1 year early	6.08
14.	As 1 but Bardheere dam 2 years late	5.18
15.	As 1 but capital and operating costs + 10% and output delayed for 1 year	1.84

The benefit accruing to the project by the implementation of Bardheere dam, i.e. the difference between the base case and case 6, amounts to SoSh 189 million over 30 years, or an average of nearly SoSh 1 000 per project hectare per year. Discounted at 6%, the incremental net benefit due to Bardheere is SoSh 56 million, or nearly SoSh 300 per project hectare per year on average.

12.6 Summaries of Costs of the Six Cases Examined

Tables 12.9 and 12.10 show, respectively, the capital costs and the total operating costs for the six cases.

12.7 Project Financing

Cost and price data were collected in mid 1979. Assuming that year 1 of the project is 1981 and that an annual rate of inflation of 15% is maintained, the financing requirements for the project would be as follows.

	Annual Costs (SoSh '000)	
	Uninflated	Inflated
Year 1	71 960	95 167
Year 2	159 309	242 289
Year 3	128 130	224 100
Year 4	18 078	36 361
Total	377 477	597 917

After year 4, project revenues exceed annual costs.

TABLE 12.9

Summary of Capital Costs (Economic) (SoSh '000)

Item	Cases studied: Base 1	2	3	4	5	Preferred option 6
Land preparation	25 717	20 441	20 441	25 717	25 717	25 717
Irrigation and drainage (including roads)	156 352	93 416	85 722	149 156	156 352	156 880
Buildings and services	60 014	41 766	41 766	60 014	60 014	60 014
Operation and maintenance vehicles and machinery	12 179	8 525	8 525	12 179	12 179	12 179
Agricultural machinery	31 389	26 330	26 330	36 902	31 389	36 284
Design and supervision	18 640	11 983	11 983	18 640	18 640	18 640
Physical contingencies	24 208	15 563	14 793	23 489	24 208	24 261
Total	328 499	218 024	209 560	326 097	328 499	333 975
Total Financial Cost	369 778	244 295	234 638	365 875	369 778	374 613

Notes:

1. Costs listed are for construction costs and initial purchase of vehicles and machinery only. Construction costs generally apply over a period of 3 years, however, the construction programme for case 5 is split and the costs apply over a period of 7 years. Initial purchase of vehicles and machinery generally occurs over the first 5 years.

2. Physical contingencies apply to the construction costs (first three items listed above) and are taken as 10% for each item. Contingencies for vehicles and machinery are included in the costs for those items.

3. No annual recurrent costs are included in the table; i.e. costs for replacement of machinery, labour, fuel and spare parts have not been included.

4. Costs include the full cost of flood protection works.

TABLE 12.10

Summary of Operating Costs
(Totals for 30 years Project Life, SoSh '000)

Case	Operating costs[1]	Machinery costs[2]
1 (Base)	1 002 727	245 770
2	663 473	177 614
3	663 473	177 614
4	1 262 327	267 454
5	1 166 006	274 306
6	1 223 219	254 344

Notes: (1) Includes all labour, fuel, oil, spare parts and agricultural inputs but excludes replacement costs.

(2) Replacement costs for all plant and machinery.

PART IV

IMPLEMENTATION

Implementation 13

CHAPTER 13

IMPLEMENTATION

13.1 Introduction

The implementation of a complete project such as the Mogambo irrigation project normally involves three separate parties:-

(a) the Employer (Project Authority)

(b) the Project Consultant

(c) the contractor executing the works.

The Project Consultant may be assisted by sub-consultants and other specialists. There may well be more than one contractor as well as others participating in the execution of the works.

Implementation concerns the organisation of three basic activities:-

(a) Setting up the Employer's organisation which will ultimately operate and maintain the project.

(b) The engineering construction

(c) The agricultral planning and execution.

The project objective is a fully operational state farm and in order to achieve this it is essential that all three organisational activities grow together. This requires the development and bringing into production of part of the area as soon as possible so that early opportunities for training staff and operational experience are provided. Thereafter, there must be progressive development to ensure that shortly after completion of the engineering works, the whole project area is under production and taken over by the Employer's organisation. Adopting this procedure will help to ensure an early return on the large capital investment.

13.2 Programme

A complete programme for the implementation of the works is shown in Figure 13.1. This incorporates the following activities:-

(a) Design and construction of the civil engineering, building and infrastructural works.

(b) Procurement of:-

(i) plant, equipment and materials

(ii) farm machinery and equipment

(iii) seed, fertiliser, spray chemicals, etc.

(c) Agricultural planning and execution, and training of personnel.

(d) Establishment of Employer's organisation.

Figure 13.2 shows a provisional programme for progressive agricultural development of the project area.

13.3 Method of Implementation

13.3.1 General

With the proposed simultaneous implementation of a number of large irrigation projects in Somalia in the near future (Mogambo, Homboy and Genale in particular) a major problem will arise in suppling the necessary Somali managerial, technical and semi-skilled staff. Whilst advantage would be taken of any staff coming available from the proposed Agricultural Extension and Farm Management project and any other sources, it is evident that sufficient numbers of Somali staff will not be available in Somalia at the start of the projects. Somali staff will have to be trained on the relevant projects over a period by staff brought in from elsewhere to start implementation of the project. The aim would be to replace expatriate staff by Somali staff as soon as the latter were capable of taking over.

13.3.2 The Engineering Construction

There are basically four possible means of effecting the construction of the project:-

(a) by Somali contractors

(b) by Somali contractors with expatriate management assistance

(c) by international contractors

(d) by direct labour.

These alternatives are discussed below.

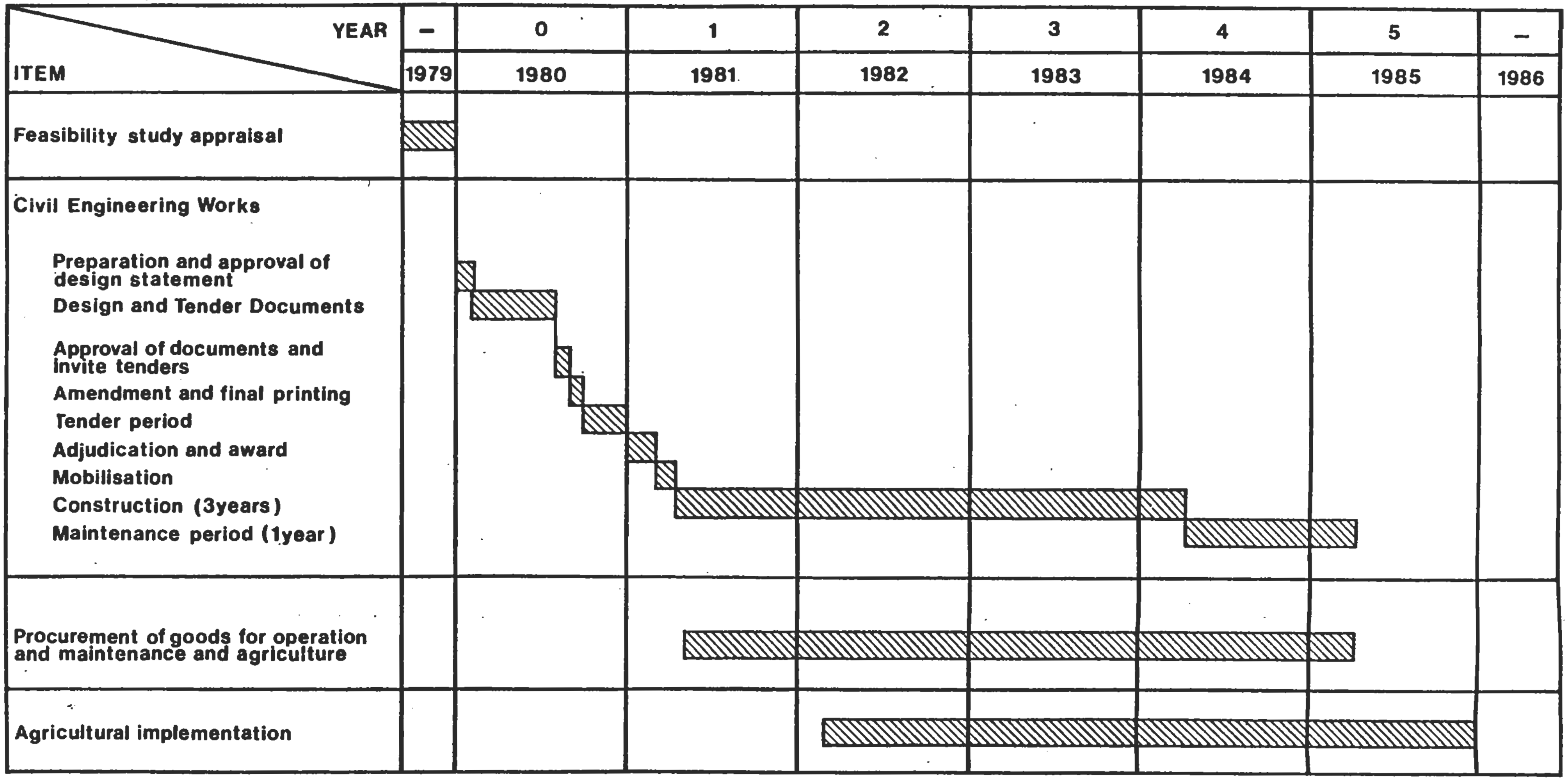
(a) The only Somali Government contracting organisation with appropriate experience is the Water Development Agency. This agency does not have sufficient resources at present to undertake a project of this size without assistance.

Private organisations such as NATCO exist in Somalia but again these do not have the resources to undertake such a large contract without assistance.

(b) This is the method currently being employed on the nearby Juba Sugar project where the Water Development Agency have the assistance of an expatriate management team comprising engineers and foremen provided from the Wimpey-Mowlem joint venture (WMJV) together with the additional assistance of a WMJV operated and maintained plant pool and quarrying organisation. All construction materials are supplied to the contractor by the Juba Sugar project.

Project implementation programme

13.1



Whereas this system is working satisfactorily on the Juba Sugar project it is doubtful whether the Water Development Agency could undertake another large project at the same time. Phase I of the Juba Sugar project is scheduled for completion in June 1982 with Phase II possibly follwing on. If implementation of the Mogambo project is to go ahead quickly it does not appear feasible for the Water Development Agency to be involved. However the possibility of their involvement should be further explored nearer the time of implementation.

Subject to the foregoing remarks, unless the private Somali contracting organisations referred to in (a) are considered for working under a similar arrangement, it is unlikely that this method could be adopted.

(c) In view of the amount of development now planned in Somalia it should be easy to attract experienced and competent international contractors to tender for the project.

(d) It is considered that this project is too large to be constructed by direct labour, unless a very slow rate of implementation is acceptable.

From the above considerations and in view of the rapid expansion of agricultural development in Somalia, it is recommended that the project be constructed using an international contractor if possible, in association with a Somali contracting organisation. The work should be advertised in the international press for prequalification of contractors, and from the response a selected list of contractors would be drawn up who would be invited to tender.

In order to ensure responsible and competitive bids it will be necessary to clarify the position of international contractors working in Somalia, particularly with regard to the recruitment of labour since the existing labour laws and organisation of the labour offices in the area are not geared for an operation of this nature. It is likely that the contractor would have to import quite a large proportion of his skilled labour.

Import and export of the contractor's plant would require to be unrestricted as far as possible. It would also be more appropriate to adopt the normal practice of the contractor being responsible for the supply of all construction materials. Accordingly some import restrictions would need to be relaxed.

13.3.3 Agricultural Planning and Execution

As discussed in Section 13.3.1, because of the large amount of agricultural development planned in Somalia at the same time as the Mogambo project, there will be a shortage of managerial, technical and semi-skilled staff in Somalia. To avoid this problem, it is proposed that a team of expatriates should be employed to assist in the early implementation. As well as organising the farm in the initial stages they would train Somali staff who would take over as soon as they were sufficiently skilled and experienced.

The proposed organisation and staff requirements are given in Annex 6, and a proposed agricultural development programme is shown in Figure 13.2. A provisional staff programme is given in Table 13.1. The agricultural development programme is planned to take four years. Each of the four farms which make up the project will be developed in turn. It is recommended that the aim should be for the post of farm manager to be filled by the Somali assistant after the first two years of operation and that the expatriate manager would then take over development of the third farm and likewise for the second and fourth farms. In this way Somali farm managers would still be able to obtain the advice of the expatriate manager for their first year in operating the farms by themselves.

Posts such as the mechanisation specialists and the processing manager are not required in the final operating organisation and therefore do not require replacements. All the remaining expatriate staff would be replaced by Somali staff promoted from within the organisation after they had received sufficient training. This arrangement would enable the maximum benefit to be obtained from the expatriate staff.

No counterparts as such are included in the staff organisation since it is considered better to promote the most able of the assistant staff rather than selecting counterparts before their ability is fully known. The proposed system also ensures that staff gain experience in executive functions early on, which is not possible in a counterpart operation.

13.3.4 Procurement

One of the most important aspects of the implementation programme is the procurement of the necessary agricultural and maintenance equipment, seed fertiliser, processing equipment and office and domestic supplies. This procurement is an extremely large undertaking and must be initiated at a very early stage in the implementation programme. In order to expedite this procurement it is proposed that the administration manager should be appointed at the beginning. He would be responsible for liaising the general manager and the Project Coordinator, through the Project Consultant's head office, who would be mainly responsible for obtaining quotations and placing the final orders.

13.3.5 The Employer's Organisation

(a) General

It is usual on projects of this nature to appoint a Project Consultant at an early stage of the implementation and this is strongly advised for Mogambo. The Project Consultant would be responsible to the general manager for co-ordinating and advising on all aspects of development of the project.

Duties of the Project Consultant would generally include:-

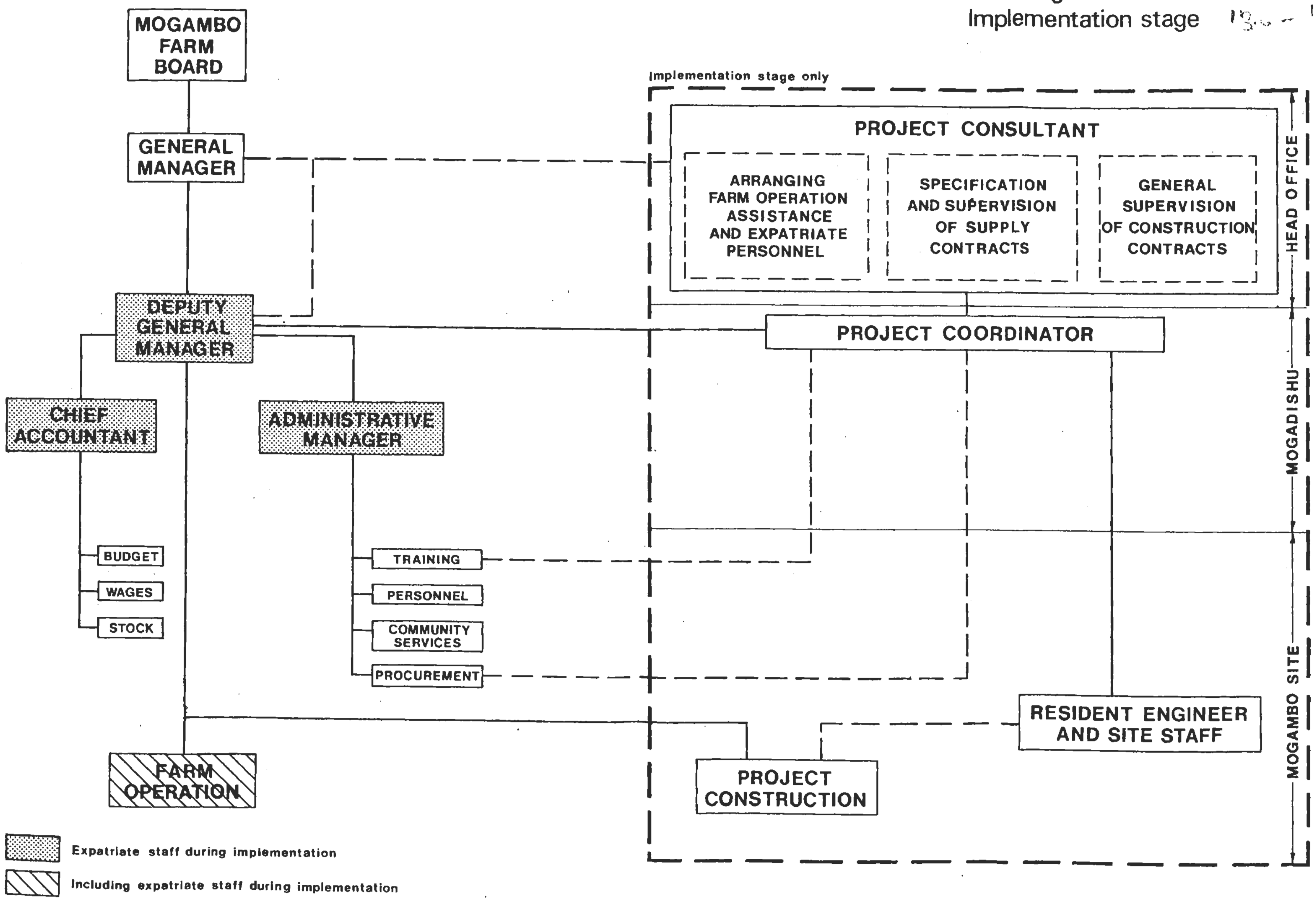
(i) Preparation of designs and tender documents for civil works, processing plant, housing and all infrastructural works.

(ii) Preparation of the appropriate documents for agricultural implementation.

(iii) Supervision of construction.

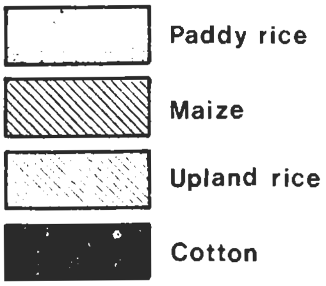
(iv) Supervision of agricultural implementation.

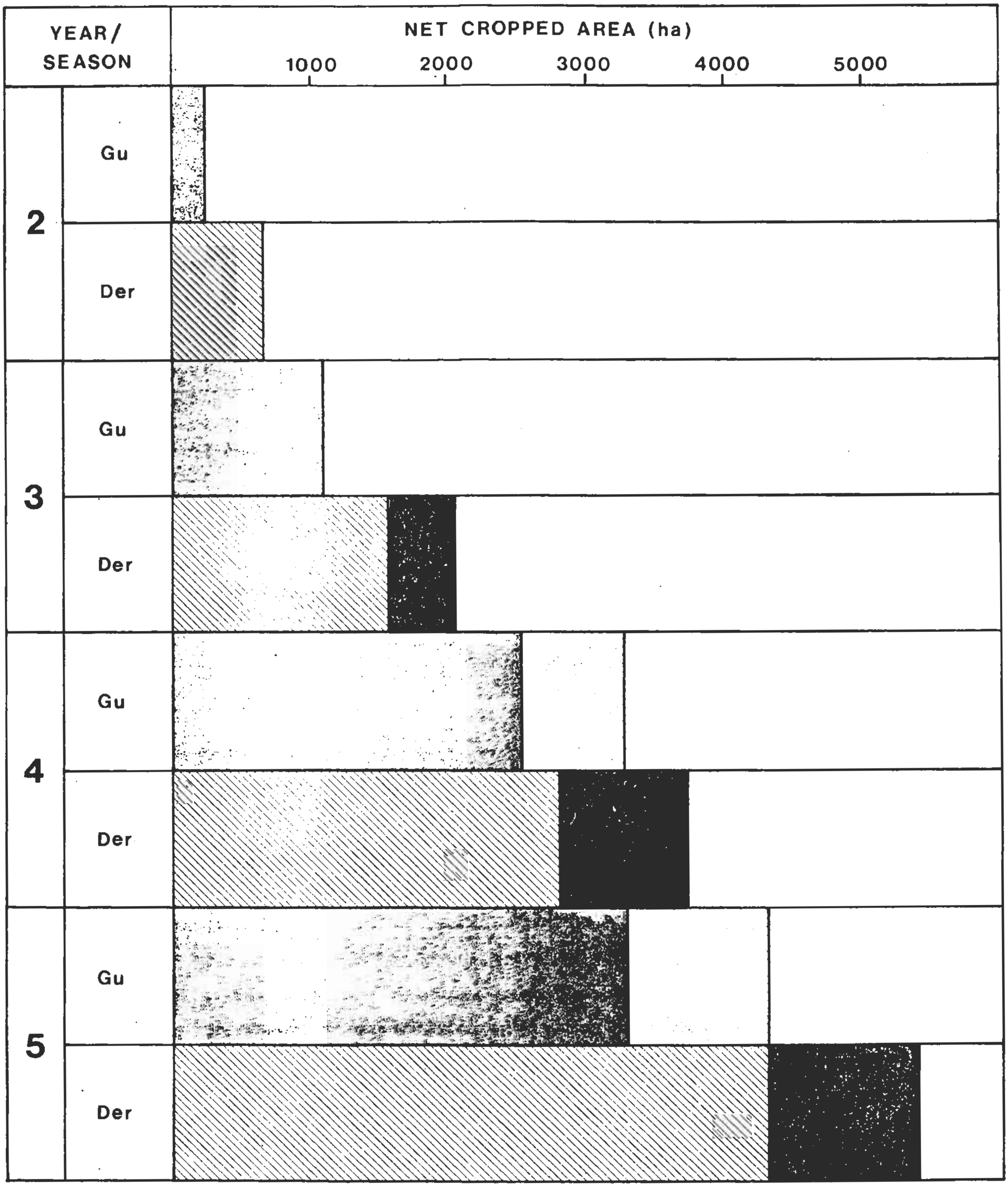
Mogambo State 13.3
Farm organisation:
Implementation stage



Agricultural implementation

13.2





Notes :– 1. Construction contract let at beginning of year 1
2. Construction complete by gu season of year 4

(v) Preparation of documents and obtaining quotations for procurement of the necessary plant, equipment and materials and placing orders following approval by the Employer.

(vi) Advising the Employer, planning and co-ordination of the various activities including operation and management.

This procedure is recommended as being a much more workable arrangement than appointing individual consultants for each part or recruiting the agricultural expatriate staff individually, since only one organisation is involved.

The Project Consultant would appoint a Project Coordinator who would be established in Mogadishu. He would have an assistant and would coordinate all the project activities and liaise with the Employer, the General Manager and the Project Consultant's head office. During the initial stages of implementation when final planning and programming would be undertaken, the Project Coordinator would have the assistance of the main expatriates employed on the project staff - namely the deputy general manager, the administrative manager, the chief accountant and the agronomist. This team would be based in Mogadishu but later the project staff would move to the project site when their duties required it.

The proposed organisation for implementation is shown in Figure 13.3.

(b) Proposed Supervision

A Project Consultant familiar with the detailed design, construction and procurement for large irrigated agricultural works, accustomed to participating with agricultural consultants and having resources for the provision of specialist services would be appropriate. Supervision of the civil engineering and infrastructure works would follow the usual practice of having a resident engineer and his staff on site supervising the contractor's work and the Project Coordinator.

Procurement would normally be carried out mainly by the Project Consultant's head office in consultation with the general manager.

Agricultural implementation could be achieved by employing an agricultural contractor under the supervision of the consultants but it may be difficult to find suitable organisations to tender for the work since there are few established firms and these are usually associated with a agro-industry having a commercial end product such as sugar or meat.

There is already a considerable amount of agricultural experience in Somalia. An alternative method would be for the expatriate staff to be provided by an agricultural management consultant or similar organisation who would have no commercial interest in the crops grown on the project. It would be the responsibility of the Project Consultant to draft suitable terms of reference for their appointment.

Both methods should be explored but it is considered that the alternative method is likely to be more appropriate for the Mogambo project.

(c) Design Stage

The design stage would be carried out entirely in the Consultants head office. It would be advantageous if one or more Somali engineers could be attached to the design team during this period. They would then return and work with the Consultant's staff on site supervision at first and later move to the permanent staff of the project. During their stay with the Consultant they would have the opportunity of becoming involved in a variety of activities concerned with the project.

(d) Construction Phase

One of the first duties of the Project Consultant would concern suitable housing for the supervisory staff so that some of it could be constructed prior to the start of the main contract. There is only a limited amount of housing available at present in the project area. The best approach would be to start constructing the project headquarters housing first and arrange the rest of the housing construction to suit the staffing programme. The earlier housing could be constructed by a local contractor under a separate advance contract while procedures for awarding the main contract are under way. It is most important for a successful start that adequate housing is available as early as possible in the implementation programme.

(e) Agricultural Implementation Phase

This is programmed to start one year after the start of construction, by which time some parts of the first farm will be ready for cultivation. In order that this can be done, it is essential that part of the Employer's agricultural organisation shoud be set up as soon as construction work commences so that all the necessary preparation can be made. Included at this stage would be the expatriate deputy general manager and the administration manager with the agronomist following approximately six months later and the first farm manager well before the start of planting.

After this the staff would build up gradually, reaching its maximum in the fifth year when the fourth farm comes into production. At this stage the expatriate staff will start to reduce and only the deputy general manager or the agronomist, the workshop manager and one farm manager would remain in year 6. The provisional staff programme is shown in Table 13.1.

As stated in Section 13.3.3 it is recommended that promotion should be from within the project so that before staff reach a position of responsibility they will have had experience of working on the project and thus will be fully familiar with the problems involved. The programme for development of the project, taking four years in all, allows enough time to train staff on the farms for this purpose.

The prospect of promotion from within the organisation should also provide incentive and encourage the maximum effort from staff at all levels.

TABLE 13.1

Project Staffing

Location	Designation	Grade	Year 1	2	3	4	5	6	7	Notes
HQ	General manager	SE	1	1	1	1	1	1	1	
HQ	Secretary to general manager	PA	1	1	1	1	1	1	1	
HQ	Internal auditor	JE	-	1	1	1	1	1	1	
HQ	Audit clerks	C	-	1	1	1	2	2	2	
HQ	Chief accountant	SE*	-	1	1	1	1	-	-	
HQ	Chief accountant	JE	-	-	-	-	-	1	1	(1)
HQ	Secretary	PA	-	1	1	1	1	1	1	
HQ	Assistant accountants	JE	-	1	1	2	3	3	3	
HQ	Accounts clerks	C	-	1	2	4	6	6	6	
HQ	Administrative manager	SE*	½	1	1	1	1	-	-	
HQ	Administrative manager	JE	-	-	-	-	-	1	1	(1)
HQ	Secretary	PA	-	1	1	1	1	1	1	
HQ	Clerks	C	-	1	1	2	2	2	2	
HQ	Training manager	JE	-	1	1	1	1	1	1	
F	Training officer	JE	-	1	2	3	4	4	4	
HQ	Personnel manager	JE	½	1	1	1	1	1	1	
HQ	Secretary	PA	-	1	1	1	1	1	1	
HQ	Clerks	C	-	1	1	2	2	2	2	
HQ	Community services manager	JE	-	1	1	1	1	1	1	
F	Community officers	JE	-	1	2	3	4	4	4	
HQ	Agricultural extension officer	T	-	1	1	1	1	1	1	
HQ	Livestock extension officer	T	-	1	1	1	1	1	1	
F	Village extension workers	T	-	-	1	2	3	4	4	
HQ	Office manager	JE	-	1	1	1	1	1	1	
HQ	Clerks	C	1	1	3	5	6	6	6	
HQ	Watchmen	L	2	12	20	20	20	20	20	
HQ	Messengers	L	2	5	10	10	10	10	10	
HQ	Drivers	SL	5	10	15	15	15	15	15	
HQ	Rest house staff	SL	2	3	4	4	4	4	4	
HQ	Building maintenance	SL	-	2	4	6	6	6	6	
HQ	Deputy general manager	SE*	½	1	1	1	1	-	-	
HQ	Deputy general manager	JE	-	-	-	-	-	1	1	(1)
HQ	Secretary	PA	-	1	1	1	1	1	1	
HQ	Agronomist	SE*	-	1	1	1	1	-	-	
HQ	Agronomist	JE	-	-	-	-	-	1	1	(1)
HQ	Seed processing manager	JE	-	-	1	1	1	1	1	

TABLE 13.1 (cont.)

Location	Designation	Grade	Year 1	2	3	4	5	6	7	Notes
HQ	Crop processing	SE*	-	-	1	1	-	-	-	(2)
HQ	Rice mill manager	JE	-	½	1	1	1	1	1	
HQ	HQ agriculturalist	JE	-	1	1	1	1	1	1	
F	Field agriculturalists	JE	-	1	2	3	4	4	4	
HQ	Secretary	PA	-	1	1	1	1	1	1	
HQ	Clerks	C	-	1	1	2	2	2	2	
HQ	Mechanics	T	-	1	3	6	6	6	6	
HQ	Labour	L	-	5	10	15	20	20	20	
HQ	Stores	T	-	-	1	1	1	1	1	
HQ	Mechanisation specialist	SE*	-	1	1	1	-	-	-	(3)
HQ	Workshop manager	T*	-	1	1	1	1	-	-	(4)
HQ	Workshop mechanics/ tradesmen	T	-	10	20	30	30	30	30	
HQ	Mobile workshop mechanics	T	-	-	2	4	4	4	4	
HQ	Workshop labour	SL	-	12	22	34	40	40	40	
HQ	Storekeeper	T	-	1	1	2	2	2	2	
HQ	Fuel pump attendant	T	-	1	2	2	2	2	2	
HQ	Truck drivers	SL	-	2	4	4	4	4	4	
HQ	Clerks	C	-	1	1	2	2	2	2	
HQ	Irrigation engineer	SE*	-	1	1	1	1	-	-	
HQ	Irrigation engineer	JE	-	-	-	-	-	1	1	(1)
HQ	Surveyor	JE	-	1	1	1	1	1	1	
HQ	Assistant surveyor	JE	-	1	2	2	2	2	2	
F	Pump operators	T	-	5	15	30	43	43	43	
F	Pump mechanics	T	-	2	4	6	8	8	8	
F	Canal maintenance foreman	S	-	1	2	3	4	4	4	
F	Canal maintenance labour	L	-	3	6	18	24	24	24	
HQ	Plant operators	T	-	2	4	6	8	10	10	
HQ	Assistant operators	T	-	2	4	6	8	10	10	
HQ	Drivers	SL	-	6	12	24	30	30	30	
HQ	Clerks	C	-	1	1	2	4	4	4	
HQ	Power station attendants	T	-	2	2	4	4	4	4	
HQ	Power station mechanics	T	-	2	2	4	4	4	4	
HQ	Water treatment works attendant	SL	-	1	1	1	1	1	1	
F	Water treatment works attendant	SL	-	1	2	3	4	4	4	
HQ	HQ farm manager	JE	-	-	1	1	1	1	1	
HQ	HQ farm storekeeper	T	-	-	1	1	1	1	1	
HQ	HQ farm labour	L	-	-	1	3	6	10	10	
F	Field inspectors	JE	-	1	2	3	4	4	4	

TABLE 13.1 (cont.)

Location	Designation	Grade	Year 1	2	3	4	5	6	7	Notes
F	Farm managers	SE*	-	1	2	2	2	1	-	
F	Farm managers	JE	-	-	-	1	2	3	4	(1)
F	Mechanisation supervisors	JE	-	1	2	3	4	4	4	
F	Irrigation supervisors	JE	-	1	2	3	4	4	4	
F	Block supervisors	S	-	2	6	10	16	16	16	
F	Gate operators	SL	-	2	4	6	8	8	8	
F	Storekeepers	T	-	1	2	3	4	4	4	
F	Assistant storekeepers	T	-	1	2	3	4	4	4	
F	Clerks	C	-	2	4	6	8	8	8	
F	Watchmen	L	-	4	8	12	16	16	16	
F	Drivers	SL	-	1	2	3	4	4	4	
F	Foremen irrigators	S	-	12	25	40	50	50	50	
F	Ditch riders	T	-	8	14	20	26	26	26	
F	Agricultural and irrigation labour	L	-	60	300	700	900	900	900	
F	Machinery operators	T	-	23	63	125	165	165	165	
	Construction Supervision (Provisional requirements)									
HQ	Resident engineer	SE*	1	1	1	1	-	-	-	
HQ	Assistant engineer	SE*	3	3	3	2	-	-	-	
HQ	Engineer/inspector	SE*	1	1	1	-	-	-	-	
HQ	Secretary	PA	1	1	1	1	-	-	-	
HQ	Clerks	C	1	1	1	1	-	-	-	

Notes:
- * Indicates expatriate
- (1) Somali replacement for expatriate
- (2) Crop processing manager replaced by rice mill manager
- (3) Mechanisation specialist not replaced
- (4) Workshop manager replaced by Somali mechanic
- SE - Senior Executive
- JE - Junior Executive
- PA - Personal Assistant
- C - Clerk
- T - Technician
- S - Supervisor
- SL - Skilled Labourer
- L - Labourer
- HQ - Project Headquaters
- F - Farm Village

The proposed agricultural development is illustrated in Figure 13.2 and detailed in Table 13.2. The first area cultivated is 243 ha of rice in the gu season of year 2 (the beginning of year 1 being the start of construction) followed by 648 ha of maize in the der season of the same year. The areas then gradually build up until year five when maximum development is reached. It should be noted that thls is an ambitious programme and any problems caused by delays or constraints will result in slower development.

Table 31.2 also shows the changeover to 1 200 ha of bananas when perennial water supplies are available following the construction of Bardheere dam. It has been assumed that planting of bananas can take place in 1987 (project year 7).

TABLE 13.2

Agricultural Implementation Schedule

Farm	Canal or pump	Area served (ha net)	Year 2 gu	Year 2 der	Year 3 gu	Year 3 der	Year 4 gu	Year 4 der	Year 5 gu	Year 5 der
A	MI/C3	243	Rice	Maize	Rice	Maize	Rice	Maize	Rice	Fallow
	MI/C1	216	-	Maize	Rice	Maize	Rice	Maize	Rice	Fallow
	MI/C2	189	-	Maize	Rice	Maize	Rice	Maize	Rice	Fallow
	P1	449	-	-	-	Cotton	Fallow	Maize	Fallow	Cotton
	P2	296		-	-	-	Rice*	Maize	Fallow	Cotton
	P3	428	-	-	-	-	Rice*	Maize	Fallow	Maize
B	MI/C4	459	-	-	Rice	Maize	Rice	Maize	Rice	Maize
	MI/C6	243	-	-	-	Maize	Rice	Maize	Rice	Maize
	M2/C2	270	-	-	-	Maize	Rice	Maize	Rice	Maize
	P4	358	-	-	-	-	-	Cotton	Fallow	Cotton
	P5	165	-	-	-	-	-	Cotton	Fallow	Maize
	P6	225	-	-	-	-	-	Cotton	Fallow	Maize
C	M2/C1	216	-	-	-	-	Rice	Fallow	Rice	Fallow
	M3/C1	162	-	-	-	-	Rice	Fallow	Rice	Fallow
	M3/C3	135	-	-	-	-	Rice	Fallow	Rice	Maize
	MT/C1	405	-	-	-	-	Rice	Fallow	Rice	Maize
	P7	190	-	-	-	-	-	Cotton	Fallow	Maize
	P8	143	-	-	-	-	-	-	Rice*	Maize
	P9	153	-	-	-	-	-	-	Rice*	Maize
D	M2/C4	351	-	-	-	-	-	-	Rice	Maize
	M3/C2	297	-	-	-	-	-	-	Rice	Maize
	MT/C2	135	-	-	-	-	-	-	Rice	Maize
	P7	213	-	-	-	-	-	-	Rice*	Maize
	P8	143	-	-	-	-	-	-	Rice*	Maize
	P9	346	-	-	-	-	-	-	Rice*	Maize
Summary of cropped areas (ha net)										
	Paddy rice		243	-	1 107	-	2 538	-	3 321	-
	Upland rice		-	-	-	-	724	-	998	-
	Maize		-	648	-	1 620	-	2 793	-	4 301
	Cotton		-	-	-	449	-	938	-	1 103
	Bananas		-	-	-	-	-	-	-	-
	Total (excluding bananas)		243	648	1 107	2 069	3 262	3 731	4 319	5 404

Note : Rice* is upland rice.

TABLE 13.2 (cont.)

Farm	Canal or pump	Area served (ha net)	Year 6 gu	Year 6 der	Year 7 gu	Year 7 der	Year 8 gu	Year 8 der
A	MI/C3	243	Rice	Maize	Rice	Maize	Rice	Fallow
	MI/C1	216	Rice	Maize	Rice	Maize	Rice	Fallow
	MI/C2	189	Rice	Maize	Rice	Maize	Rice	Fallow
	P1	449	Rice*	Maize	Bananas		Bananas	
	P2	296	Fallow	Maize	Rice*	Maize	Bananas	
	P3	428	Fallow	Cotton	Rice*	Maize	Bananas	
B	MI/C4	459	Rice	Fallow	Rice	Maize	Rice	Maize
	MI/C6	243	Rice	Fallow	Rice	Maize	Rice	Maize
	M2/C2	270	Rice	Fallow	Rice	Maize	Rice	Maize
	P4	358	Rice*	Maize	Fallow	Maize	Rice*	Maize
	P5	165	Fallow	Cotton	Fallow	Maize	Rice*	Maize
	P6	225	Fallow	Maize	Rice*	Maize	Fallow	Cotton
C	M2/C1	216	Rice	Maize	Rice	Maize	Rice	Maize
	M3/C1	162	Rice	Maize	Rice	Maize	Rice	Fallow
	M3/C3	135	Rice	Maize	Rice	Maize	Rice	Fallow
	MT/C1	405	Rice	Maize	Rice	Fallow	Rice	Maize
	P7	190	Fallow	Cotton	Fallow	Cotton	Rice*	Maize
	P8	143	Fallow	Cotton	Fallow	Cotton	Rice*	Maize
	P9	153	Fallow	Cotton	Fallow	Cotton	Fallow	Cotton
D	M2/C4	351	Rice	Maize	Rice	Fallow	Rice	Maize
	M3/C2	297	Rice	Maize	Rice	Fallow	Rice	Maize
	MT/C2	135	Rice	Maize	Rice	Maize	Rice	Maize
	P7	213	Rice*	Maize	Fallow	Cotton	Fallow	Cotton
	P8	143	Fallow	Maize	Fallow	Cotton	Fallow	Cotton
	P9	346	Fallow	Maize	Fallow	Cotton	Fallow	Cotton

Summary of cropped areas (ha net)

	Year 6 gu	Year 6 der	Year 7 gu	Year 7 der	Year 8 gu	Year 8 der
Paddy rice	3 321	-	3 321	-	3 321	-
Upland rice	1 020	-	949	-	856	-
Maize	-	4 379	-	3 740	-	3 232
Cotton	-	1 079	-	1 188	-	1 080
Bananas	-	-	449		1 173	
Total (excluding bananas)	4 341	5 458	4 270	4 928	4 177	4 312

Note : Rice* is upland rice.