HOMBOY AREA AND SMALLHOLDER BANANA CULTIVATION IN THE LOWER JUBA VALLEY AND ASSESSMENT OF AGRICULTURAL BENEFITS

This report comprises the following volumes:

Main Report

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CHAPTER 1

INTRODUCTION AND BACKGROUND

1.1 Introduction

The Lower Juba valley has been a major producer of irrigated bananas for export for many years. Further expansion of the industry has been restricted by seasonal shortages of irrigation water and frequent flooding. Construction of Bardheere dam should remove both these constraints, thus enabling production in the existing banana areas to be intensified and allowing the development of banana growing in new areas such as Homboy.

Present production is based on medium scale commercial farms averaging 61 ha of bananas per farm. The Government now wishes to involve smallholders in the industry and has therefore included a pre-feasibility study of smallholder banana production as one of the three main components of the current study. The main aims of this part of the study are to assess the future market for increased banana output and exports, to review present production problems and cropping patterns, to propose ways of involving smallholders in this crop, and to identify and plan the development of an area suitable for a pilot scheme to test the feasibility of smallholder production for the overall assessment of the total benefits of the Bardheere dam. The scope of work also involved the collection of data and the preparation of cropping plans and detailed financial analysis for large scale smallholder banana production on the Homboy scheme, where 3 000 ha have been identified as being suitable for irrigated bananas.

Field trips to the Lower Juba valley were undertaken in October and November 1986, when a total of 12 banana farms were visited, representing both large and small growers, some employing a high standard of management and others of mixed ability. Much help was given by the General Manager of the Somalfruit Horsted farm, Mr. Mario Barogi, and the Technical Manager of Somalfruit in Araba, Mr. Carlo Blanco, and his assistants. Professor Mohammed Dahir, one of the team's counterparts, who was until recently the General Manager of the Strengthening Agricultural Production Project (SAPP), proved to be an invaluable source of information, with wide contacts among farmers in the Juba valley. Data were also collected from the many reports on the Juba valley, in particular the Agrar und Hydrotechnik (AHT) studies on deshek, rainfed and irrigated agriculture. The Somalfruit company's head office staff and, in particular, Mr. A. Olivetti, the General Manager, were most helpful in providing the relevant statistics and background information.

Many reports have suggested updating the technology currently employed in Somalia, on the basis of techniques of production used in other banana producing areas. However, Somalia's dry and windy climatic conditions and heavy, poorly drained soils are very different from the virgin humic soils found in the humid tropics of Central and South America, and transferring the technologies developed in these areas to Somalia would be hazardous, unless the techniques adopted follow a long period of adaptive research in Somalia. As such research facilities are not available, the technology described in this study and the recommendations given are based on improving the methods already tried and proven under Somali conditions. Yield projections and crop longevity are therefore conservative, and it is recognised that in time these could be improved as knowledge and experience are gained, particularly if research is given priority in future development.

Yields throughout this study are based on the average yield per cropped area and are expressed in tonnes of exported fruit per hectare. This is in compliance with the accepted international definition of yield. The records for Somalia show yield as tonnes of 'exportable yield' per hectare and 'tonnes of exported fruit' per hectare, the area defined as 'area in production, that is, over 12 months old'. As production commences after 9 months this somewhat over-estimates yields. Somalfruit defines area as 'the number of plants divided by the planting density, that is 2 000 plants per hectare, and as this does not take into account the roads, pathways and waterways, it somewhat underestimates the area, thereby overstating the yield. Banana yields vary over the life of the crop, and under Somali conditions this may be from 100% in year 2 to less than 50% in year 3.

An average yield over the life of the crop is required for budgetary calculations. For the assessment of future areas of production, the standard convention of dividing the exported yield by the planted or 'cropped area', as defined by the Somalfruit formula for planted crops, has been adopted for the calculation of yields in this study. This may underestimate yields per hectare when compared with previous studies, as the comparisons in Table 1.1 show, but it is felt that this convention gives a truer guide to yields and areas and comparisons with the published figures from competing countries.

TABLE 1.1

Comparison of Yield by Definition

	1972	1973	1974	1975	1976	1977	1978
1. Total area under production (ha)	9 178	9 770	9 039	8 342	7 422	6 383	6 831
2. Total area in production ha(1)	7 137	7 054	6 721	6 148	5 319	4 547	4 605
3. Exports (tonnes)	103 314	133 934	111 931	107 298	81 840	72 531	53 811
4. ENB yield (t/ha) (3÷2)	14.5	18.9	16.5	17.4	15.2	15.9	11.7
5. Study yield (t/ha) (3÷1)	11.3	13.7	12.3	12.7	11.0	9.7	7.9

Note: (1) Area in production = plantations over 12 months old.

Source: ENB statistics 1978.

1.2 Brief History of Banana Development in Somalia

The commercial production of bananas in Somalia was pioneered in the mid-1920s by Italian farmers whose main objective was to exploit the new and expanding banana markets in Italy. With the encouragement of the Italian Government, in giving favoured status to its colonies, production of bananas in Somalia, and in the Juba valley in particular, flourished until British occupation between 1939 and 1945, when all the plantations were put down to rice production. Italian farmers rebuilt the industry in the 1950s, supplying fruit to the State Banana

Monopoly in Italy which had complete control over purchasing, shipping, distribution and prices in Italy. Again, Somalia enjoyed preferential access to this market, and banana production increased steadily (see Table 1.2). Production in the Lower Juba increased rapidly between 1950 and 1974, providing 31% of all Somalia's exports in 1950 and over 61% in 1974: the mid-1970s were a period of peak production.

A tax on banana consumption, introduced by the Italian Government in 1965 to compensate for the loss of revenue from the State Banana Monopoly, favoured Somalia, whose production was rated at lire 60/kg compared with lire 90/kg for produce from other sources, but this tax was unified at lire 110 kg in 1970 and raised to lire 525/kg in 1985. This tax, in conjunction with increasing competition from other tropical fruits, probably accounted for the decrease in per capita consumption of bananas in Italy since 1970, from 6.1 to 5.3 kg.

With the closure of the Suez Canal in 1968, exportation was via the Cape, necessitating at least a further 7 days' sailing and significantly increasing costs. Post-independence emigration by the Italian farmers led to a serious decline in the industry and by 1978 production had fallen to almost 57 000 tonnes, with less than 7 000 ha farmed. In the Juba valley, the production area was reduced to under 3 000 ha and production to below 25 000 tonnes.

Low prices paid to growers, probably as a result of problems in marketing and organising exports, particularly to the Middle East market, coupled with acute shortages of foreign exchange and the resulting lack of inputs, caused the area and production to decline further until the early 1980s when a scheme sponsored by the Italian Government aimed at reviving the industry was introduced. Run by Italian experts the new scheme has produced a general increase in yield since 1980, as shown in Table 1.2.

1.3 Organisation and Supporting Services

From 1943 to 1968 banana production in the Lower Juba valley was organised through a growers shareholding company, SAG, which provided inputs and technical assistance as well as arranging the transport and exporting through the port of Kismayo. In 1968, SAG amalgamated with an equivalent company operating in the Shebelle area called SACA to form a general shareholding company Somalbanane SpA, with a marketing subsidiary in Italy, Societa Mercantile Oltremare (SMO), which was responsible for distribution and marketing in Italy. In 1970, Somalbanane was nationalised to form the National Banana Board (ENB - Ente Nationale de Banane) which took over all the functions of Somalbanane, including its 75% share in the marketing agent SMO. The ENB was organised as a semi-autonomous organisation of the Ministry of Agriculture. It developed its own farms and established its own nursery.

Since 1983, following the economic liberalisation within Somalia generally, Somalfruit has formed a joint venture company with the ENB, with 60% of the shares owned by Italian interests and 40% owned by the ENB. The management is Italian, and the Government, through the Ministry of Agriculture, is represented on the Board of Directors and appoints the company President.

Somalfruit is now the only organisation responsible for the industry. Its responsibilities and functions include:

- being the sole exporter of the country's banana crop;

- marketing, through its agent CAMAR;

TABLE 1.2

Exports of Banana 1950 to 1985
(tonnes)

Year	Total	Shebelle	Juba
1950	17 496	12 158	5 338
1951	25 152	17 159	7 993
1952	31 400	25 310	6 089
1953	30 688	17 824	12 864
1954	40 640	27 494	13 320
1955	45 605	32 580	13 025
1956	32 860	17 976	14 884
1957	39 092	27 694	11 398
1958	50 337	34 311	16 026
1959	54 148	33 254	21 884
1960	76 854	49 601	27 253
1961	78 538	48 666	29 872
1962	77 234	54 546	22 688
1963	97 184	60 373	36 811
1964	102 847	60 211	42 636
1965	98 828	60 569	38 260
1966	94 243	50 545	43 699
1967	84 813	41 368	43 445
1968	86 585	42 869	43 716
1969	92 818	42 373	50 545
1970	102 844	40 186	60 058
1971	103 314	36 709	66 605
1972	133 934	60 652	73 282
1973	111 931	46 723	65 208
1974	107 299	41 469	65 830
1975	81 841	34 995	46 846
1976	72 531	33 874	38 658
1977	53 812	28 812	25 000
1978	57 079	32 861	24 218
1979	36 657	na	na
1980	35 491	na	na
1981	34 255	19 182	15 073
1982	50 665	28 879	21 786
1983	62 448	34 970	27 478
1984	47 855	26 321	21 534
1985	45 325	24 926	20 399

Source: Somalfruit 1970 to 1985, ENB Statistics 1978.

- arranging the collection of export fruit from its own and private packing plants;

- supervising the quality of fruit packed at the 12 private packing plants, through a team of inspectors;

- transporting harvested fruit from private farms to one of the five Somalfruit packing plants;

- importing most of the inputs, such as fuel, fertilisers and chemicals, together with tractors, pumps, machinery and spare parts for resale;

- providing medium-term, interest-free, credit for machinery;

- operating a factory and workshop for the manufacture of spare parts and the servicing of machinery;

- operating a factory for the manufacture of cardboard packing cartons;

- providing technical assistance.

Somalfruit's head office is in Mogadishu, with a regional office and its own cardboard box making factory at Araba, near Jamaame, where the stores, workshop and factory are sited. There is also an export office at Kismayo.

Local growers act individually in their relationships with the company, as there is no formal growers' organisation to represent them collectively. They appear to be producing their crops speculatively, without a contractual arrangement with Somalfruit. However, the company has an obligation to accept bananas for export and, apart from a few isolated grievancies expressed in the course of field interviews, the system appears to work well.

Technical and field services in the Juba valley are provided by Somalfruit's technical department located at Araba and headed by an Italian technical manager. There are six trained advisers who also inspect and enforce quality standards on the farms with private packing facilities. Further advice is provided by the General Manager, and his two assistants, of Somalfruit's own farm at Horsted.

ONAT, the Government owned machinery hire service, also provides machinery and tractors for hire to the banana farms.

There are four State farms growing bananas, each part of the Ministry of Agriculture's SAPP, the objective of which is to rehabilitate abandoned farms for eventual resale to the private sector. There are no co-operative banana farms. Details of the State farms are given in Table 1.3.

Apart from these farms, the Ministry of Agriculture and its associated extension services, such as AFMET, is not directly involved in the banana industry, although the experimental farm at Afgoi can provide limited soil testing services. There are no pathological, entomological or tissue analysis services available to banana growers.

TABLE 1.3

SAPP State Farms - Areas in hectares

Farm Nr	Size	In bananas	New planting	Total bananas
44	360	50	-	50
21	140	30	15	45
23	140	30	-	30
viv	120	20	10	30
Total area	760	130	25	155

Source: Ministry of Agriculture's SAPP, Jamaame.

1.4 Marketing and Exports

Prior to 1983 all Somali bananas were marketed by the ENB subsidary company SMO. Since 1983 Somalfruit appointed CAMAR in Italy to act as commission agents for all exports. The bananas are sold both in the Middle East and Italy under the brand name 'Somalita' and are packed in 12.5 kg net weight cardboard boxes. Although the international markets other than Saudi Arabia prefer the traditional 18 kg or 40 lb box the requirements of the Saudi Arabian market dictate the use of the small size carton. Somalfruit argue that it is uneconomical to market two sizes and supply the Italian market with this small carton. As the carton cost can be 25% of the grower's price, this appears to be an expensive strategy.

A few years ago Marka was one of two ports from which bananas were shipped, and it served the Shebelle region. Now all bananas are shipped through Kismayo where extensive facilities have been built. However, this involves a 250 km journey for the Shebelle fruit on deteriorating roads, and quality is inevitably sacrificed necessitating a further inspection at Kismayo. Juba valley fruit, on the other hand, has a relatively short journey, some 45 km, on a reasonable road.

The values of exports since 1983 are shown in Table 1.4.

The price the grower receives is determined by Somalfruit and it has risen considerably since 1983, from SoSh 245 per quintal (100 kg) to the present price of SoSh 1 500 in December 1986. These prices and the margins taken by the ENB and Somalfruit are presented in Table 1.5.

Since 1971, the overall trend in banana exports has been a decline, as shown in Table 1.2. In 1971 exports were 103 315 t and growers received 87% of the export price. For comparison, in 1985 exports were 45 325 t and growers received only 46% of the export price. Since 1985, however, the farmgate price has improved; the grower of high quality fruit receiving SoSh 17 000 with an average price of 15 000 being paid to most growers. This highlights one important fact; a pricing policy which appears fair to the producer is the only way to encourage the production of agricultural crops in general, and bananas in particular, as the international banana market prices and competitors' FOB prices are well known to all producers. If the farmgate price does not keep pace with the export price, disillusionment sets in, inputs are reduced and production declines.

TABLE 1.4

Banana Export Prices 1983-1986
(US$ FOB Kismayo)

Year	Total value	Exports (tonnes)	Value per tonne
1983	8 559 016	62 448	137
1984	9 366 980	47 855	196
1985	13 236 039	45 325	292
1986	12 000 000[1]		

Source: Somalfruit

Note: (1) Provisional estimate

TABLE 1.5

Grower Prices and Agent's Margins (per tonne)
1971-1986

	Farmgate price (SoSh)	FOB export price (SoSh)	ENB/Somalfruit margin	
			(SoSh)	Percent of FOB price
1971	540	619	79	13
1972	540	584	44	8
1973	540	604	64	11
1974	540	686	146	21
1975	680	986	309	31
1976	750	1 217	467	38
1977	750	1 216	466	38
1978	750	1 221	471	38
1979	750	na	na	-
1980	820	na	na	-
1981	1 640	na	na	-
1982	1 700	na	na	-
1983	2 450	na	na	-
1984	4 750	7 800	3 050	40
1985	9 300	20 164	10 864	54
1986	12 000 Sep)			
1986	15 000 Dec)	27 900	12 900	46

Source: FAO Report to Somali Government, SOM/81/015.

CHAPTER 2

THE BANANA INDUSTRY IN THE LOWER JUBA VALLEY

2.1 Introduction

Bananas have been grown in the Lower Juba valley for many years being production based on medium-scale commercial plantations with an average banana area of 61 ha.

Smallholders do not grow the crop, which is not a popular source of carbohydrate in Somalia, unlike the situation found in many banana growing countries. However, they are employed as labourers in the banana plantations and therefore have some experience of production methods. The areas of bananas grown and the export yields have fluctuated widely over the years and a full review of the present industry, including the agronomy and production methods, was considered an essential prerequisite to developing a strategy for smallholder involvement.

2.2 Physical Conditions

2.2.1 Soils

Bananas are grown mainly on the levee soils flanking either side of the river bank. These soils, often stratified, have a dominant clay content with a texture ranging from silt clay loam to sandy loam. Salinity levels are generally low but increase with depth. The soils are calcareous with a moderately high soil pH which could give rise to nutrient deficiencies in the banana crops.

Although the levee soils are reasonably fertile and relatively easy to cultivate, drainage problems are apparent on many farms. Much of the premature yellowing, toppling and low productivity may be due to waterlogging and poor aeration rather than other problems such as nutritional deficiencies, pests and diseases.

Away from the levee soils, the cover floodplains are formed of expanding lattice clays exhibiting typical properties of deep cracking and self-mulching. On these soils natural drainage is poor, demanding a very high standard of management for banana production to succeed.

In general, all the soils in the area are low in organic matter and this, coupled with the high clay content and poor drainage, significantly limits yield potential. Though shallow rooted, the banana is intolerant of both poor aeration and poor drainage.

The area of good Class I soils in the Juba valley was estimated by Impresit in 1979 to be about 12 000 ha. Much of this land is some distance from the river and would require extensive irrigation works to enable banana production to be carried out. Perhaps the best estimate of the area suitable for banana production is the 8 287 ha identified by AHT in 1983 (Section 2.3). Most of this land is registered to established farmers and the future expansion in the area is likely to come from these farmers developing and expanding production on this land.

2.2.2 Climate

The climate is tropical semi-arid with a mean annual rainfall of about 430 mm falling mainly during the gu (April-May/June) and der (October-November/December) seasons. For crops such as bananas frequent irrigation is therefore essential. The gu rains are heavier and more reliable than in the der and in both seasons the rain falls as heavy storms rather than uniform precipitation. This causes damaging flooding, requiring adequate surface drainage on the banana farms to prevent root death through waterlogging.

The 3-month long jilaal dry season (December/January-March) is characterised by persistent, moderate north-east winds, with an average speed of 1.5 m/s, occasionally gusting to high speeds (7.5 m/s) for many days. The xagaa dry season (June/July-August/September) is characterised by cool cloudier weather and persistent strong south-west winds averaging 2.5 m/s. These winds cause the characteristic tearing of the leaves of the banana plants which is probably not deleterious in itself but could cause scarring and bruising of developing fruit, making it unfit for export. The strength of the wind is unlikely to cause toppling of mature healthy plants but its persistence is likely to limit potential yield by the constant rocking of the plant. This causes crown distortion and broken roots, thereby increasing the risk of disease and nematode infection.

However, this breeze, coupled with the very low rainfall, a relative humidity of about 70% and abundant sunshine of over 240 hours/month is probably the reason for the almost total absence of normal and black Sigatoka disease (Mycosphaenella masicola and M. fizcensis), locally known as 'Cercospora', which is a major and expensive problem limiting production in other banana growing countries.

2.2.3 Water and Flooding

Water for irrigation is extracted from the river by suction pumps sited along the banks. Water availability is of extreme concern to the producers, as low water levels occur almost every year in the jilaal season; occasionally the river even dries up completely. Since few have groundwater supplies available (a large proportion of the limited number of existing wells produce water which is too saline for irrigation) the jilaal low flows cause major problems. With the lower river levels and resultant greater pumping head, more pumping is needed than in the rest of the year, with 24 hour operation often being necessary. Even then, supplies may be inadequate, especially as crop water requirements are highest in this season. Jilaal water shortages cause reductions in banana yields and quality and some plant deaths. Many farmers complain that water shortages have increased since the development of large-scale irrigation projects, such as Juba Sugar and Fanoole, situated upstream of the banana area.

During the first few days of rising river water levels, the salinity of the river water is high. Much damage is done to plants already under stress, by growers irrigating with this water. There is, at present, no regular monitoring of salinity levels in the river by banana growers to prevent this from happening.

Perhaps an even greater problem is flooding, which has occurred with increasing frequency in recent years. Serious flooding was recorded in 1977, 1981 and 1985. Many growers complain that the construction of flood protection bunds on the large farms upstream has increased the problem of flooding in the banana area.

2.2.4 The Effect of Flooding and Drought on the Banana Plant

Flooding is very serious, as death will result if the plant stands in water for more than 4 days. The effect of water stress is more insidious even though the crop is fairly drought-resistant and the crop is frequently grown under rainfed conditions in countries with a pronounced dry period, such as Uganda, where the main production occurs after the rainy season.

The flowering and bunch size of a banana plant depends on previous growth, fruit development depends on contemporary events and total yields depend on the continuity and vigour of renewed growth. Thus the banana makes high demands on a continuous supply of water. Even a short period of 14 to 21 days drought occurring just after flowering would result in physiological disasters, such as distorted and withered fruits and a loss of quality and yield together with delayed growth of the following ratoon crop, probably amounting to a crop loss of 5 to 10%.

With the longer periods of water shortage that often occur in the jilaal season the loss would be correspondingly greater. Increasing water shortage causes wilting, loss of vigour and fruit disorders, such as premature ripening and malformation. Prolonged water stress will cause the stems to break and collapse, with a cessation of renewed growth. A drought of 60 days could reduce yields by over 50%, as new growth stimulated by the recommencement of irrigation would take 9 months to crop, thereby losing one or two ratoon crops.

The consequences for the local farmer of the frequent droughts and of flooding are serious, as interrupted cash flows, coupled with the difficulties of obtaining short-term credit, impose a serious strain on financial resources. This is most serious following a flood when finance is needed to replant, prepare land and reconstruct irrigation channels. In many cases farmers are forced to react by reducing inputs, thereby compounding the problem.

2.2.5 The Suitability of the Local Environment for Banana

As the banana plant is a native of the wet, humid tropics, the environmental conditions prevailing in Somalia are far from ideal and the yield potential, when compared with crops grown in the major banana growing regions, such as South and Central America, is likely to be lower. However, many of the disadvantages of the local conditions can be overcome. Windbreaks such as Casuarina spp would reduce the damaging effects of the constant wind; well-designed drainage schemes would alleviate the serious drainage problems and major capital works in flood control and providing a regular supply of irrigation water, such as the Bardheere dam would do, would reduce the risk of crop losses due to flooding and drought. The major problem is the soil. Although bananas are grown throughout the world on a variety of soils, the best crops are usually found on deep, well drained humic soils. The poorly drained, heavy clay soils found in the area require the highest standard of management to produce commercial yields and are probably a major factor in the very short life of the crop. Most commercial crops in Central and South America have a life in excess of 10 to 20 years compared with an average crop life of 3.2 years in the Lower Juba valley (AHT, 1984). Although poor management and poor nematode control contribute to the short life of the crop, the underlying cause is undoubtedly the nature of the soils.

The success of the industry over the years is a reflection of the growers' ability to adapt the crop to the environment and, in particular, to manage the soils correctly: an important factor if inexperienced smallholders are to be encouraged to cultivate bananas.

2.3 Areas of Production

Banana farms flank either side of the Juba river from Kamsuuma down to Yoohtoy. According to the AHT photographic reconnaissance survey carried out in 1983, 8 287 ha were identified as either existing or abandoned banana farms. The historical maximum area under production, 5 075 ha, was reached in 1973, and as AHT estimated that the normal area under fallow, following previous banana crops, was approximately 40% of the total area, it can be assumed that about 8 500 ha has at one time or another been cultivated with banana. The cropped area in 1983 was estimated by AHT to be 3 315 ha. Somalfruit calculated the true cropped area to be 2 571 ha, as at December 1984, using the formula of dividing the total number of plants by the planting density of 2 000 per hectare. Its estimate of the present area at August 1986 was 2 276 ha, the fall from the 1984 figure being due to the serious flooding which occurred in 1985.

Table 2.1 shows the banana areas from 1970 to August 1976, these figures probably underestimate the total area under banana production, as they take no account of the roads, drains and waterways.

TABLE 2.1

Banana Areas in the Juba Valley, 1972 to 1985 (ha)

Year	Juba valley	Somalia	Percentage of national area in the Juba valley
1972	4 428	9 128	48
1973	5 075	9 770	52
1974	3 964	9 037	44
1975	4 133	8 342	50
1976	3 435	7 422	46
1977	2 488	6 383	39
1978	2 820	6 831	41
1979	-	3 816	-
1980	-	3 214	-
1981	1 804	4 100(1)	44
1982	1 650	4 800(1)	21
1983	2 052	4 700(1)	44
1984	2 571	4 492	55
1985	2 010	5 121	39
1986 (Sept)	2 276	5 839	39

Note: (1) Estimates.

Source: Somalfruit.

With a 3-year crop life and a 4-year crop rotation, the fallow area should be 25%. However the area fallowed on the less well managed farms can be as high as 40%, greatly under-utilising the scarce Class I land resources. Increasing the crop life to 4 years would reduce the fallow area to 20% of the total area and enable more land to be in banana production.

2.4 Holding Size

According to Somalfruit, there are now 54 banana growers in the area, the sizes of the individual holdings varying from 2.75 to 541 ha (see Table 2.2). Recent plantings indicate a trend towards larger holdings.

TABLE 2.2

Size of Banana Holdings in the Lower Juba Valley

Farm size (area in bananas[1]) (ha)	Number of holdings In production	Planted[2]
0 - 5	6	2
6 - 10	7	5
11 - 25	23	17
21 - 50	13	21
51 - 100	3	7
over 100	1	2
Total	53	54

Notes: (1) Cropped area according to Somalfruit calculation.
(2) As at August 1986.

Source: Somalfruit.

There are four State farms growing bananas (total banana area 155 ha), each being part of the Ministry of Agriculture's SAPP. There are no co-operative banana farms. All the remaining farms are privately owned; some are under Italian management, but the majority are owned and managed by Somalis.

Somalfruit also owns and manages its own estates. It is the largest single producer in the area (present banana area 541 ha) and is currently carrying out a rapid expansion programme, approaching 20 ha of new plantings per month.

2.5 Management Systems

There are two distinct systems of management, one employing high inputs and applying a medium level of technology, the other adopting low inputs and the traditional low level of technology.

(a) Medium Level Technology

The well-managed farms are following the example set by Somalfruit on its own farms. On these farms, particular emphasis is given to land levelling and water control, in view of the major problem of localised waterlogging, frequently caused by inaccurate land levelling. This is considered to be important enough to justify the use of expensive laser levelling equipment. An error of 2 to 3 cm in the grading has an adverse effect on productivity.

A standard block size of 3 ha has been adopted, with a maximum row length of 100 m, claimed to be the optimum length for efficient water distribution. A recent improvement has been the installation of a piped irrigation layout, with gate valves feeding the supply channels to each block and the furrows fed by 50 mm syphon tubes. With this system it is claimed that a larger area can be irrigated daily with less labour.

The standard single furrow is used for planting and after full crop establishment, about 3 to 4 months after planting, a wide furrow is drawn between the plants serving two purposes:

(i) to fill in the plant furrow, effectively 'earthing-up' the developing pseudostem to increase its resistance to wind damage;

(ii) to prepare a wide irrigation furrow.

Few farms have installed the pipe system, but the general principles of levelling and the system of adapted furrow irrigation are closely followed. A further feature on all these farms is the attention given to cultural details such as hygiene, weed control, fertiliser and chemical applications and pruning. Up to 20 qt/ha of fertiliser are generally applied.

(b) Low Level of Technology

The majority of farms are still using traditional methods of culture typified by a low standard of husbandry, infrequent pruning and low inputs, particularly in the form of fertiliser and chemical applications.

Many use less than 10 qt/ha of fertilisers and a feature of these farms is the poor control of grass weed, such as Cynodon dactylon. Levelling is carried out casually and localised waterlogging accounts for the very uneven growth apparent on many of these farms.

Irrigation is along furrows for the first few months, by which time the furrows become silted up. Bunds are then formed by tractor and ridger, and subsequent irrigation is by the basin-flood method.

Standards of hygiene are low, with trash frequently blocking the water flow in the basins.

2.6 Crop Husbandry

Most of the operations on the banana farms, with the exception of land preparation and transporting harvested fruit, are done by hand.

Broadly, the methods of husbandry and the recommendations for crop production are the same for both the management systems described in Section 2.5. The differences between the two systems concern the willingness and ability, due to financial constraints, to adopt the recommendations, and attention to detail.

2.6.1 Land Preparation and Planting Dates

Following the initial land levelling by bulldozer, the land is ploughed by tractor and mould-board plough. Four-wheel drive tractors or 70 to 100 hp crawlers are used. The primary objective of ploughing is to control weeds particularly couch grass (Cynodon dactylon), as banana roots are intolerant of competition from grass roots.

Ploughing starts once the gu rains have finished in July and the land is left fallow for 3 to 6 months in order to obtain good control of the weeds.

Prior to planting the land is disced, sometimes twice, to produce a workable tilth and this is followed by the preparation of planting furrows using a 'V' ridger.

The final operation takes place at any time of the year, but the possible shortage of water experienced in the jilaal and xagaa dry seasons (see Section 2.2) means that the majority of farmers prepare for planting in time for either the der or gu rains.

Table 2.3 gives the approximate tractor operating times as estimated by the technical staff at Somalfruit.

TABLE 2.3

Tractor Operating Times

Operation	Hours per hectare
Ploughing	3 to 5
Disc harrowing x 2[(1)]	3.0
Preparing furrows	9.0
Preparing secondary furrows[(2)]	9.0
Mechanical weeding[(3)]	1.0

Notes: (1) Occasionally by a single pass.
(2) 3 to 5 months after planting (see Section 2.5).
(3) During first 4 to 6 months after planting.

In general the standard of ploughing is poor, with equipment badly set up and the job rushed.

2.6.2 Cultivars

The cultivar Poyo (syn Robusta) is universally grown, although Guande Naire (syn Williams) and Valley, introduced in 1964, are now being grown on a few farms. These three are probably the most widely grown cultivars in commercial production throughout the major banana exporting countries, replacing the older tall varieties such as Lacaton and Guos Michel.

Valley and Poyo are similar, growing to 3 to 4 m, and belonging to the Robusto, clone in the Cavendish sub-group, whereas the shorter cultivar Guande Naire, 2.5 to 3 m, belongs to the Giant Cavendish sub-group within the same Cavendish clone.

All three cultivars retain the dead female flower on the tip of the banana fingers at harvest and this is a major cause of fruit damage both by wind and during post-harvest operations.

2.6.3 Propagation and Planting Material

Maiden suckers, i.e. large pseudostems of about 20 to 25 cm in diameter, are preferred as planting material, although it was observed that many farms use much smaller suckers. Most suckers are collected from abandoned banana fields and show heavy infestations of burrowing nematodes (Radopholus similis) and banana weevil (Cosmopolites sondidus). The collected suckers are cleaned by cutting the dead roots and infected parts of the corm away, an operation which generally was seen to be badly done. Inspection of prepared planting material on many farms showed that nearly all the planting material was infected with Cosmopolites sondidus, indicating that control of the pest is becoming a major problem in the area, a fact confirmed by Somalfruit's technical staff. Few farms have nurseries and not one farm practises the severe trimming, heat treatment and disinfection methods described in Chapter 4 to produce disease-free stock.

The pseudostem of the selected suckers is trimmed to 30 to 50 cm prior to planting upright in the furrows.

2.6.4 Planting

The planting furrows are spaced at 2.5 m and planting holes are roughly dug by yambo, the local short-handled hoe, at 2 m apart. This spacing gives a planting density of 2 000 per ha. Current recommendations advise placing a handful of fertiliser, about 150 g of DAP, and a measure of Furadan (30 g) to each hole prior to planting. The sucker is placed vertically in the hole and soil is firmed around the corm, and the first irrigation is applied immediately.

2.6.5 Replanting

A proportion of suckers fail to grow, due in many cases to localised water-logging and poor quality planting material. These are replaced with fresh suckers 2 to 3 months after the initial planting.

2.6.6 Pruning and Tapining Systems

It is recommended practice to remove the young shoot emerging from the centre of the cut pseudostem (the heart growth), although many farmers allow this to develop. This growth rarely gives heavy yields and the strongest of the developing side suckers is normally selected for cropping as the plant crop. Pruning or desuckering is then carried out at about 45-day intervals, removing all the developing suckers with the yambo. Every 4 months a strong sucker is allowed to develop as the follower producing future crops. In general, pruning is poorly carried out, which delays maturation and fruit development, and the selection and positioning of the followers is arbitrary, resulting in a loss of distinct 'niets' and variability in plant vigour, with subsequent crop loss.

Leaf pruning is carried out, but in general is badly done with long petioles left and dripping latex contaminating the fruit. Many authorities consider leaf pruning to be harmful and recommend that it is restricted to removing the leaves which rub against the developing fruit causing scarring. Given the persistent winds which occur in the area, heavy leaf pruning may, however, be desirable, but on many farms visited, the leaf rubbing against the bunch had not been removed whilst many others had.

Fruit developing on the outside rows is protected from sun scald by bending and wrapping a leaf around an exposed bunch and tying it securely to prevent scarring.

General practice is to remove the male flower after the last 'false' hand has developed and de-handing this incomplete hand is not practised.

Although the removal of the flowers is recognised as being a possible treatment for reducing the serious post-harvest losses, in some cases exceeding 50%, it is generally felt that the operation is too skilful for the present labour force and could result in even greater crop losses.

2.6.7 Weed Control

Weed control is a serious problem until the crop canopy covers the ground, when it effectively shades out the weeds. Unless the weed growth, particularly the grasses such as couch (Cynodon dactylon), is controlled at an early stage, the crop vigour suffers and the canopy is not dense enough to control subsequent weed growth.

On well-managed farms thorough land preparation prior to planting followed by one or two inter-row cultivations by tractor and cultivator, plus regular spot weeding by hand, is sufficient to control weeds until the crop canopy closes. Subsequent weeding is then limited to occasional hand weedings. Efficient crop management and high levels of fertiliser application on these farms causes vigorous banana plant growth, forming a dense canopy which shades out the weeds.

There are many poorly managed farms, where weed growth is a major problem resulting in poor crop vigour. This compounds the problem by exposing the weeds to sunlight thus encouraging more growth. These farms therefore experience a weed problem throughout the life of the crop, as the canopy is insufficient to smother and shade out the weeds. Mechanical cultivation is only possible for the first 3 to 4 months, as late cultivation increases damage to the developing surface roots and, apart from reducing crop vigour, allows the entry of nematodes and disease.

Herbicides, in particular ametayne (Gesapax 500 FW), have been used in the past but poor control and suspected crop damage has been reported and this form of treatment is no longer recommended.

Thorough cultivations, timely hand weeding and producing vigorous crops have been shown to be the most effective methods of weed control.

2.6.8 Irrigation

Irrigation intervals vary for the following reasons:

(a) During the jilaal season irrigation is applied every 10 to 15 days, whereas during the gu season every 3 weeks is sufficient, depending upon the frequency of the rainfall.

(b) Drainage problems, soil type and the age of the plantation dictate irrigation frequency. Poorly drained fields require a longer irrigation interval and percolation rates tend to become longer as the age of the plantation increases.

(c) Periodic Water Shortages

On average, growers irrigate every 10 to 15 days, with between 25 to 27 irrigations a year. Actual quantities applied are not known although, with the piped system on Somalfruit's own farm, a reasonably accurate system of application has been developed by knowing the output of each gate valve and applying water to a standard sized block, 3 ha, for a given period of time. Apart from this farm, no method of regulating or determining application rates is practised and optimum requirements are difficult to judge as a result of poorly levelled land, localised water-logging, soil compaction and variable crop growth.

Many farms appear to over-irrigate, yet few possess an adequate surface drainage system which would alleviate any sub-surface drainage problems. In many cases, where surface drains do exist, poor maintenance and blocking with crop trash reduces the efficiency of the system. Surface salinity, observed on many farms in the form of surface encrustation of salt deposits, confirmed by taste, does not appear to be a major problem, particularly on the well managed farms practising sound irrigation principles.

2.6.9 Fertiliser Applications

Somalfruit imports three fertilisers, urea (46% N), di-ammonium phosphate (DAP-20N:50 P_2O_5) and a compound NPK (15N:7P:24K). These are sold to banana farmers at a common price of SoSh 2 100 per quintal. The single price was introduced after representations by growers about the high price of fertiliser other than urea. There are no alternative fertilisers imported, Somalfruit claiming that limiting the range to these three enables them to purchase in bulk quantities, thereby reducing the cost.

Recommended fertiliser rates are 18 to 21 qt/ha, a rate shown to improve productivity on the Somalfruit farm yet many growers apply less, in some cases as low as 3 to 5 qt/ha.

There would appear to be no scientific basis for the choice of fertiliser and, in the absence of a soil laboratory with tissue analysis facilities, corrective applications of nitrogen, phosphate, potash and trace elements are not carried out. There is much evidence of micro-nutrient deficiencies, possibly induced by poor soil conditions and the high pH, particularly iron (Fe), yet Somalfruit considers it impractical to import those fertilisers containing micro-nutrients, on the grounds of cost and the unlikely use made of them by growers.

Somalfruit's fertiliser recommendations, as shown in Table 2.4, call for regular applications every 6 weeks. The most usual frequency is, however, much less, with some growers fertilising only 2 to 3 times a year.

TABLE 2.4

Somalfruit Fertiliser Recommendations

Fertiliser N:P:K percent rate application	Urea 46:0:0 (g/plant:qt/ha)		DAP 20:50:0 (g/plant:qt/ha)			Compound 15:7:24 (g/plant:qt/ha)	
At planting	-	-	150		3	-	-
At 4 months	80	1.6	-		-	-	-
At 5.5 months	-	-	-		-	100	2
At 7 months	180	3.6	-		-	-	-
At 8.5 months	-	-	-		-	100	2
At 10 months	100	2	-		-	-	-
At 11.5 months	-	-	-		-	100	2
Total 1st year	360	7.2	150		3	300	6
Thereafter every 6 weeks							
Alternative	100	2	-	or	-	100	2
TOTAL	450	9	-	plus	-	450	9

Source: Somalfruit.

2.6.10 Pest and Disease Control

One of the big advantages Somalia has over other major producers is the almost total absence of the serious diseases such as: Panama disease (Fusarium oxysporum) Sigatoka (Mycosphaerella musicalo and M. fijiensis), Moko disease or bacterial wilt (Pseudomonas solanacearum) and Bunchy Top virus.

Aerial spraying every 6 months with oil (cuiveral plus mineral oil) as a prophylactic against Sigatoka, locally known as Cencospora, was practised but is now rarely carried out. As the effective treatment is phytotoxic and because of the very low incidence of the disease this would appear to be sound practice, provided that corrective action is taken if an outbreak should occur. The risk period would be during the gu or der rains.

Apart from the post-harvest benonyl dip (see Section 2.6.12) no disease control measures are carried out. The major problems are the two pests: root-burrowing nematode (Radopholus similis) and banana weevil (Cosmopolites sordidus). Both of these cause severe crop losses and contribute to the short life of the plants. The only method of control adopted in the area is the systemic insecticide/nematicide Carbofuran (Furadan 10 G) at the recommended rates of:

At planting	30 g/plant
Every 6 months	30 g/plant
(equivalent to 120 kg/ha per year)	

The chemical is expensive (SoSh 360 per kilogram) and many growers apply Furadan at lower than recommended rates, some giving only a single dose at planting.

The dependence on this one chemical is of some concern as well as being bad practice, as tolerance to Furadan will inevitably result, particularly on farms where sub-optimal levels of treatment are carried out. As nematode and weevil are so serious, a range of insecticide and nematicide should be made available. Such chemicals would include the insecticides gamma BHC and diazinon, and nematicides such as Miral and Oxymil (Ugdate).

Sucker cleaning and disinfection is not carried out, but the method described in Chapter 5 would provide clean planting stock and thus reduce the initial infection.

Other pests such as rust thrips (Chaetanaphotrips orchidic) and the virus vector banana aphid (Pertatonia riquonavosa) do not appear to be serious and would be controlled by the Furadan treatment.

2.6.11 Harvesting

The stage at which the bunch is considered ready for harvesting is determined by Somalfruit's export quality standards, which demand under-ripe fruit with a diameter of between 33 and 35 mm. The recommended stage is when the outer central finger of the second hand from the top is measured with a caliper carried by the cutters. Many cutters, however, were observed selecting by eye.

The first harvest commences from 9 months after planting and about 80 to 90 days from 'shooting', the emergence of the flower from the pseudostem. Selected stems are cut at the base and the bunches are lowered onto a padded fibreglass headboard and taken to the edge of the field, where they are collected and transported to the packing station. The frequency of harvesting bananas is based on the arrival of the ships at Kismayo; on average these arrive every 8 to 10 days.

2.6.12 Packing

Harvested fruit is either collected by Somalfruit for grading and packing in one of its five well-equipped packing stations or packed in one of the 12 private farms having packing facilities. These are supervised by Somalfruit, to ensure a uniform export quality.

The process in all plants is similar, although some of the private farms' packing plants are somewhat rudimentary. On arrival the fruit is handled as follows:

(a) The bunches are slung onto an overhead carrier and the fingers are deflowered.

(b) The hands are removed with a thin sharp knife, badly damaged fingers are discarded and placed in the first of two washing tanks.

(c) Grading and selection is followed by reducing the hands to convenient cluster.

(d) The selected clusters are placed in the second wash tank for the removal of latex and a final grading is made, to remove blemished fruit from the cluster and discard clusters of less than four fingers.

(e) The selected fruit is dipped into small treatment tanks containing a benonyl (Beniate) solution and then placed onto a plastic tray for weighing.

(f) The fruit is weighed (14 kg) before packing into a polythene bag placed in a cardboard carton; the air is removed from the polythene bag by vacuum, the polythene fastened and boxing completed.

The net weight of the export box is 12.5 kg. Over-weighing at the packing stage allows for the natural shrinkage which occurs from packing to point of retail sale.

The standards of packing and quality are quite good. To achieve these the amount of fruit rejected for export is high, depending on the individual grower's level of management. In many cases the rate of rejection is over 50%. The cardboard box is produced by a company owned by Somalfruit and this 12.5 kg pack, including the plastic liner, costs SoSh 50, almost 25% of the farm-gate price. The international standard is 18 kg and substantial savings could be made if this size was used. However, Somalfruit claims that the Saudi Arabian market demands the small size and it would be uneconomical to market two sizes, one for Italy and one for Saudi Arabia.

2.7 Yields

Banana yields are normally expressed as yields of exported fruit per hectare. This is significant because in many countries fruit rejected as export fruit can exceed 50% of the harvested crop.

The many reports on Somalia's banana industry give a confused picture, Impresit (1979) claiming that 35 t/ha export and 5 t/ha reject was achieved in the past, La Rosa (1966) stating that 30 t/ha was possible, and MMP (1979) estimating export yields of 13 t/ha. The Impresit figure of 35 t/ha in 1979 would have placed Somalia up with the best producers in the world. With the local standards of management, inputs, soils, climate, water shortages and flooding this is unrealistic.

The annual exports are well recorded (Table 2.5) but the method of calculating the hectarage, as described in Section 2.3, varies considerably. The cropped areas quoted in the past by the ENB, and since 1983 by Somalfruit (Table 2.5), underestimate the true farm size by not including roads, alleyways, waterways and fallows, but include the area of recently planted crops yet to bear.

The 'production' area quoted in the ENB statutory reports relates to the area over 12 months old. This too is misleading if used for calculating yield, as a plant crop produces 50% of its annual harvest on its first cut, usually 9 months after planting.

The area under banana as calculated by Somalfruit probably gives the fairest indication of export yield per hectare and these yields are presented in Table 2.5.

TABLE 2.5

Banana Yields in the Juba Valley 1972-1985

Year	Fruit exports (t)	Area planted (ha)	Export yield (t/ha)(1)
1972	73 282	4 428	16.5
1973	65 208	5 078	12.8
1974	65 830	3 964	16.6
1975	46 846	4 133	11.3
1976	38 658	3 435	11.3
1977	25 000	2 488	10.0
1978	24 218	2 812	8.6
1979	na	na	na
1980	na	na	na
1981	15 073	1 804	8.3
1982	21 786	1 650	13.2
1983	27 478	2 052	13.4
1984	21 534	2 571	8.3
1985	20 375	2 010	10.1

Note: (1) Total net area planted.

Source: ENB statistics 1970 to 1978.
Somalfruit 1979 to 1985.

Somalfruit's latest figures show that yields for the last 2 years were 10.6 t/ha in 1984 and 8.8 t/ha in 1985 and the company reports that reject rates of 50% were frequently necessary. The most common figure quoted in field interviews was 28 t/ha with 20% rejected for export. Somalfruit's own farms, where the standard of management is very high, report these figures; the Somalfruit target export yield on good land is 25 t/ha. The conclusion must be drawn that the majority of growers are aiming for 28 t/ha but that few achieve this level. The standard of management and, in particular, the quality of fruit examined on many farms clearly suggests that the majority of farms produce total yields below 20 t/ha, with export reject rates above 50%.

Total yields tend to be highest in the second year, falling dramatically in subsequent years. Typical patterns for the different management systems are shown in Table 2.6.

TABLE 2.6

Typical Annual Crop Yields

	Medium technology	Low technology
Year 1		
tonne/ha	14	14
per cent	50	100
Year 2		
tonne/ha	28	11
per cent	100	80
Year 3		
tonne/ha	24	7
per cent	85	50
Year 4		
tonne/ha	14	terminated
per cent	50	
Year 5		
tonne/ha	terminated	-
per cent	-	-
Annual average (tonne/ha)	20.0	10.6

Source: Study data.

There are many factors affecting productivity and these have been discussed fully in previous sections of this chapter. Broadly, they fall into three categories; management, post-harvest care and the effects of drought and flooding. The first two are under the control of the grower. The effect of drought and flooding, discussed in detail in Section 2.2.3, is out of the control of the grower and can, in severe cases, reduce the potential yield by over 50%.

Although banana technology has dramatically improved worldwide in the last decade, enabling yields of 50 t/ha to be achieved on the virgin lands of South and Central America, it is considered unrealistic to budget for yields in excess of those currently being achieved in the Lower Juba valley on well managed farms; i.e. 20 t of export fruit per hectare. The effect of improved water supplies after the construction of the Bardheere dam would be to reduce export rejects and increase yields, the 20 t/ha figure, which is double the existing yield, reflecting this.

2.8 Marketing and Prices

Packing is scheduled according to the arrival of the ships at Kismayo port, which call at roughly 8 to 10 day intervals, and cutting and loading is spread over 3 days. Fruit of a minimum of 170 mm length and a girth of between 33 and 35 mm and unblemished, is of export quality. The growers receive a price according to Somalfruit's determination of quality, as shown in Table 2.7.

TABLE 2.7

Farm-gate Prices for Bananas in November 1986

Quality (%)	Grower price (SoSh per quintal)
100	1 740
90	1 500
80	1 320
Less than 80	rejected

Source: Somalfruit.

Somalfruit's responsibility ends at the loaded FOB stage, with marketing in Italy and the Middle East being handled by their agents CAMAR under the brand name Somalita.

With fiercely competitive international shipping prices and a world surplus of bananas, a competitive FOB price is of importance.

The low yields combined with the need for frequent replanting, which is expensive, contribute to the relatively high FOB price of over US$ 300 per tonne in 1984. Typical competitors FOB prices are shown in Table 2.8.

TABLE 2.8

FOB Purchasing Prices for Selected Competitors 1984

Source	FOB price (US$/t)
Philippines	277
Ecuador	262
Central America	289
Somalia	305

Source: FAO.

Fruit rejected for export is sold to local merchants who buy ex-farm at a price of between 300 to 400 SoSh/qt and transport the fruit to the urban areas for re-sale. Prices paid to growers from 1972 to 1984 are shown in Table 1.5 in Chapter 1.

2.9 Labour Requirements

A detailed survey of the labour requirements for a banana crop in the Juba valley was carried out by AHT in 1983 and a summary of its findings is presented in Table 2.9.

TABLE 2.9

Labour Inputs for Bananas - Lower Juba Valley

Operation	Man-days per hectare
Planting(1)	15
Irrigation	138
Irrigation maintenance	54
Crop maintenance	230
Guarding	50
Harvesting and packing	108
TOTAL	595

Source: AHT, 1984.

Note: (1) Averaged over 3 years.

These labour inputs are high when compared with competing countries, where the labour requirement can be as low as 150 man-days per hectare excluding irrigation. This suggests a low productivity from the labour force, a fact confirmed during field visits to farms.

Many of the operations are in fact carried out by piece work or by contract and typical rates quoted during field interviews are detailed in Table 2.10.

TABLE 2.10

Contract Labour Rates 1986

Operation	Rate (SoSh)	Unit
Lifting suckers	0.40	each
Carting suckers	0.30	each
Preparing suckers	0.30	each
Distribution	0.50	each
Digging holes	0.50	per hole
Fertiliser placement	0.20	per plant
Planting	0.60	each
Pruning	100.00	ha
Harvesting	1.00	bunch(1)
Weeding	1 000.00	ha

Source: Field study data.

Note: (1) Plus rejected fruit.

None of the farmers interviewed complained of difficulties in obtaining labour, although a few were concerned about the quality and productivity of the labour available. Much of the work is undertaken by women.

2.10 Costs and Returns From Existing Farms

With the wide variations in management, inputs and yields, the net returns and profitability of a typical farm are difficult to assess. For the purposes of this study however, a 'high input' and 'low input' farm have been considered.

Using rates quoted by Somalfruit and shown in Table 2.11, the cost of crop establishment has been calculated as SoSh 156 600 per hectare. This is equivalent to an annual cost of SoSh 52 200 per hectare for a low input farm (3 year crop) and SoSh 39 150 per hectare for a high input farm (4 year crop).

TABLE 2.11

Crop Establishment Rates

Operation	Rate (SoSh/hour)
Land preparation:	
Tractor and plough	920
Bulldozer levelling	1 500
Lining	920
Ditching	920
Grading	1 600
Reforming canals	1 500
150 m drains	1 500
Tractor and discs	920
Preparing furrows	920
Planting and replanting	14 000
Mechanical weeding	600

Source: Somalfruit.

The calculated costs are approximate only and total establishment costs are similar in both high and low input farms. The main difference between the two types of management would be in crop longevity; the well managed farms with longer-lived crops would thus achieve a lower annual charge for crop establishment.

The overall crop production costs and returns per hectare are presented in Table 2.12 for both high input and low input farms. The table indicates a gross margin of SoSh 119 020 per hectare and SoSh 27 770 per hectare for the high and low input farms respectively.

The sensitivity of these margins to hazards such as the jilaal droughts and low river levels can be demonstrated by the gross margin matrix as in Table 2.13.

TABLE 2.12

Crop Production Costs and Returns Per Hectare

	High input farm			Low input farm		
	Unit	Rate (SoSh)	Cost (SoSh)	Unit	Rate (SoSh)	Cost (SoSh)
COSTS						
Hand weeding	20X	1 000	20 000	4X	1 000	4 000
Pruning	4X	3 000	12 000	6X	100	600
Cleaning:						
(1) Drains	1X	4 400	4 400	1X	4 400	4 400
(2) Canals	1X	6 000	6 000	1X	6 000	6 000
Furadan	120 kg	350	42 000	30 kg	350	10 500
Fertiliser	18 qt	2 100	37 800	5 qt	2 100	10 500
Chemical application	18X	50	900	4X	50	200
Bunch bags	2 000	3	6 000	nil	-	-
Harvesting	2 000	1	2 000	1 500	1	1 500
Transport	2 000	2	4 000	1 500	2	3 000
Irrigation fuel	990 l	27	26 730	990 l	27	26 730
Supervision) Drivers) Mechanics)	-	-	20 000	))		10 000
Spares) Taxes) Petrol)	-	-	20 000	)))		10 000
Management			12 000			12 000
Planting and land preparation	4 year crop		39 150	3 year crop		52 200
TOTAL			252 980			152 230
RETURNS						
Export	24 t	15 000	360 000	10 t	15 000	1 50 000
Local	4 t	3 000	12 000	10 t	3 000	30 000
TOTAL	28 t		372 000	20 t		180 000
GROSS MARGIN	ha		119 020			27 770

Source: High input - Somalfruit.
Low input - own calculations and field data.

Notes: X Number of times for each operation.

TABLE 2.13

The Effect of Decreasing Yield on Gross Margin

Yield (%)	Gross margin (SoSh/ha) Low input farm	High input farm
100	27 770	119 020
85	3 000	66 390
50	-60 000	-63 890

Source: Table 2.12.

The effect of drought could, however, be more serious, as quality is affected as well as yield. The table clearly shows that all farms are likely to suffer acute financial losses in the years of prolonged drought.

2.11 Scope for Improvement and Expansion

2.11.1 Technical Improvement

The previous sections have described in detail the production methods and the likely response of the banana plant to the environmental conditions and cultural practices in the Lower Juba valley. The three areas which affect productivity and profitability are management, post-harvest care and water supply.

Management standards on the best farms are high and should be a model for the majority of farmers to copy. It is unlikely, however, that the relatively low yields of 24 to 28 t/ha produced on these farms - when compared with those achieved in competing banana areas, such as the 40 to 50 t/ha now being produced in the Uraba region of Ecuador and on the virgin lands of Honduras - could be increased by improved culture, due mainly to the physical constraints discussed in Section 2.2.

Further, the suitable soils along the Lower Juba valley have been in and out of production for well over 50 years and are thus old banana soils, unlikely to have the same yield potential as virgin soils, even with high inputs of chemicals to control the latest pest and disease problems.

Production costs are high due mainly to the short life of the crop, requiring the establishment of new crops every 3 to 4 years and placing between 20% to 40% of good land into fallow. As crop life is short, total yields over the life of the crop area are low, as the yield significantly declines after the second year.

The main areas for improvement are therefore seen to be the life span of the plant, management and post-harvest care. The methods for achieving these aims are summarised as follows:

(1) Establishing nurseries for the production of disease-free planting material, as described in Chapter 5.

(2) Planting of well sited windbreaks such as Casuarina to reduce the damage to fruit by leaf scarring and to prevent crown distortion and toppling.

(3) Paying particular attention to land levelling and drainage to reduce localised waterlogging.

(4) Planting a green manure cover crop such as sunhemp (Crotalaria) on fallowed land.

(5) Controlling nematode and weevil by following the recommended chemical treatment (Furadan 10 G at 120 kg/ha). This, combined with clean stock, should increase the life of the plant from 3 to possibly 6 years on the best drained soils.

(6) Maintaining plant vigour by applying the recommended quantity of fertiliser; i.e. 18 to 20 qt/ha.

(7) Improving post-harvest operations by deflowering in the field, and improving the supervision of the cutting, carrying and loading of trailers.

(8) Providing the harvesting trailers with a canopy to protect the harvested fruit from the sun.

(9) Maintaining good farm roads to prevent damage in transport.

A further refinement of post-harvest care would be the introduction of field boxing, a technique developed in the Windward Islands for smallholder production which, it is claimed, reduced the reject losses to less than 25%. The system involves dehanding in the field and partial grading prior to packing in plastic field boxes of about 30 kg which are then transported to the packhouse. Damage in transit, caused in the main by the crushing of the fruit when complete bunches are loaded, is reduced to a minimum. Field boxing is reported to have been tried unsuccessfully in the past, but the introduction of the new Windwards Islands technique should have a much greater chance of success.

2.11.2 Structural Improvements

Although there have been spasmodic attempts at developing research and experimental centres, such as CARS at Afgoi, there is at present no research centre for bananas. Further, and of more concern, is the absence of reliable soil, pathological and entomological facilities. For an industry as important as banana in the Somali economy such facilities are considered essential in order to monitor and advise on the control of pests, disease and nutritional problems. Current advice has no scientific base and, as such, may be erroneous.

The almost total absence of the major diseases, such as Sigatoka, Moko and Bunchy Top virus, which are the scourge of most banana producing countries and require expensive remedial action, gives Somalia a unique commercial advantage over its competitors. Although the climatic conditions may be the reason for the low incidence of disease, the fear that pests and disease could be introduced and adapt to Somali conditions is of great concern. In the absence of well supervised quarantine facilities, it is recommended that no planting material be introduced from outside Somalia.

Stock of the most popular commercial varieties - Poyo, Guande Naire and Valery are available in Somalia and there would thus appear to be no case for the introduction of other varieties, such as Williams or Ziv, which are, in fact, synonymous or very similar to the standard varieties.

2.11.3 Expansion Opportunities

(a) Pre-Bardheere Dam

The two major constraints on present expansion are flooding and drought. With continuing upstream development both these problems are likely to increase, thereby making immediate expansion and development of the area a hazardous and high risk proposition.

The exploitation of export markets is increasing dependent upon the regular supplies of high quality fruit (see Chapter 3). Flooding and drought, therefore, result not only in loss of yield and quality and reduced viability of the farms but also in the possible loss of export markets.

It is doubtful whether further major expansion can be sustained without the assurance of regular supplies of water and adequate flood control which Bardheere will provide.

(b) Post-Bardheere Dam

The construction of Bardheere dam will regulate flooding and improve water supplies in the Juba valley, thereby removing the major constraints on present production of frequent flooding and drought.

Expansion of the banana industry in the area would therefore be restricted to the availability of suitable land and the size of the export market. Market projections, discussed in Chapter 3, suggest that there is opportunity for 225 000 t of export fruit to be produced in Somalia. For commercial reasons, such as guaranteeing supplies of a particular quality, it is desirable for an export industry to produce in excess of the market requirement. A gross area of 11 000 to 12 000 ha in the Juba valley, together with the maximum area possible of 5 000 to 6 000 ha in Genale would be needed to satisfy this market. If all the 8 200 ha identified by AHT in its photo reconnaissance study of 1983 was put back into production by the existing banana farmers, a further 3 000 to 4 000 ha would have to be found for further development. New irrigation schemes such as the Homboy development could therefore be exploited for banana production. As the existing farmers are likely to be fully occupied in expanding their own farms an opportunity exists for involving smallholders in the banana industry.

CHAPTER 3

MARKETING AND MARKET PROSPECTS

3.1 Introduction

Banana production worldwide differs from most other agricultural commodities in that harvesting is a continuous year round activity and is not confined to a particular season, and under normal weather conditions there are negligible seasonal fluctuations in supply. Only under extreme climatic conditions such as hurricanes and floods are export shortfalls likely, and when these occur the shipper and importer can respond quickly by diverting vessels to adjacent sources of supply. Only when these extreme weather conditions occur in several adjacent producing countries, are sustained shortfalls likely to happen. There are therefore no out-of-season high price opportunities to exploit, although there is a small seasonal price variation in many European importing countries.

3.2 The Internatonal Market

3.2.1 World Trade

The Latin American countries of Guatemala, Honduras, Costa Rica, Panama, Colombia and Ecuador provided nearly 70% of the world trade between 1970 and 1983, as shown in Table 3.1.

TABLE 3.1

World Trade in Bananas ('000 tonnes)

Year	World imports	Latin American exports	Percentage of world trade
1960-1965	4 422	-	-
1966-1970	5 542	-	-
1971	6 249	-	-
1972	6 477	-	-
1973	6 449	4 426	69
1974	6 388	4 021	63
1975	6 390	3 949	62
1976	6 326	4 021	66
1977	6 549	4 263	65
1978	6 967	4 496	65
1979	7 070	4 690	66
1980	6 853	4 620	67
1981	6 970	4 671	67
1982	6 787	4 699	69
1983	6 120	4 177	68

These figures show a significant growth in world trade during the 1960s and 1970s and a disturbing reduction since 1979. Possible reasons for this fall are:

- the rise in oil prices in 1973;

- these countries also experienced a doubling of inflation rates in the same period;

- reduced population growth rate in many European countries;

- governmental action such as the increase in banana consumption taxes in Italy.

International trade in bananas is highly competitive and quality at the point of sale is a vital consideration.

3.2.2 The Preferential Market

These are the markets in European countries traditionally supplied by former colonies or departments (the African, Caribbean and Pacific, ACP, countries) and protected by the Lomé conventions. This provides exemption from the EEC Third Country Tariff, which is currently 20%. The most recent convention, Lomé III, was signed on the 8th December, 1984, and is in force until 1990.

In this market, trade flows from Martinique, Guadeloupe, Ivory Coast and Cameroons to France; from Jamaica and the Windward Islands to the United Kingdom; and from Somalia to Italy. Included in this market is the 'domestic' production from the Canary Islands to Spain and from Madeira to Portugal. About 24% of world trade falls into this category.

The share of the ACP suppliers in the United Kingdom and Italy has declined sharply in recent years, due to production problems and unfavourable pricing policies in certain producing countries. This has resulted in a reduction of the area cultivated, as farms become uneconomic.

The failure of the ACP countries to supply their European markets in full has resulted in 'dollar fruit' (that from Latin America) taking an increased share of the preferential market (see Section 3.2.4). The damaging effect of this is not just the loss of market share, but also the introduction to the buying public in these countries of fruit of exceptional quality which has to be matched if the ACP countries' market share is to be regained.

3.2.3 The Open Market

This market covers the remainder of world trade; dollar fruit from Central and South America supplying the USA, Canada and the non-preferential markets of Europe and the Philippines supplying Japan. The Middle East is supplied from all sources. Included in this category is the trade from the Pacific Islands to New Zealand, the self-sufficient Australian market and the small trade between some of the South American countries, i.e. Ecuador to Argentina and Chile.

This market faces few, if any, quantitative restrictions on the origin or volume of banana imports and the suppliers are flexible according to market conditions in different importing countries. The open market is dominated by the activities of three multi-national trading companies.

3.2.4 The Role of the Multi-national Corporations

United Brands, Castle and Cooke, and Del Monte play a dominant part in the world banana trade. These companies are vertically integrated between production and purchase of bananas in the open market exporting countries and the sale of fruit and distribution into the wholesale trade of the importing countries.

The share of these companies in world banana trade has increased over the last two decades despite attempts by some exporting countries to diversify marketing options. Their larger share was a result of their satisfying the growth in world trade during this period and making good the failings of the ACP countries in supplying the preferential markets. Details are given in Table 3.2.

TABLE 3.2

The Share of the Multi-national Corporations in the World Banana Market ('000 tonnes)

Year	United Brands (t)	United Brands (%)	Castle and Cooke (t)	Castle and Cooke (%)	Del Monte (t)	Del Monte (%)	Total (t)	Total (%)
1966	1 807	34.0	652	12.3	58	1.1	2 505	47.4
1972	1 973	30.5	1 168	18.0	356	5.5	3 497	54.0
1980	1 966	28.7	1 451	21.2	1 053	15.4	4 470	65.3

Source: FAO

The corporations are engaged in production in Central America, where they own or operate large individual plantations of up to 5 000 ha. They also operate associated producer programmes in which fruit is sold to them under contract by the local producers.

They are engaged in shipping, ripening and distribution in most importing countries, although in the United States legal restrictions prevent importers from ripening and distribution.

Their commercial and market strength make entry for any newcomers to the trade extremely difficult, although some companies such as the Union de Bananaos de Uraba (UNIBAN) in Colombia, has successfully broken away and markets independently.

3.3 The Italian Market

As an ACP country, Somalia enjoys preferential status on this 300 000 t market, yet has seen its share of trade slip to under 6%, dollar fruit now dominating the market (see Table 3.3).

TABLE 3.3

The Italian Market for Bananas (annual averages)

Year	Imports ('000 tonnes)	Per capita consumption (kg)	Market share (%) Somalia	EEC/ACP	Dollar fruit
1970-1972	328.7	6.1	24	13	63
1973-1975	325.1	5.9			
1976-1978	306.6	5.4	10	16	74
1979-1981	311.7	5.5			
1982	330.0	5.8			
1983	304.8	5.3			
1984	309.4	5.3	6	4	90

Source: FAO

Although consumption has fallen slightly, probably as a result of increased competition with other tropical fruits, the market has been relatively constant, at around 300 000 t/year. Imports are controlled by quota arrangements. Although under this system a licence is required for Somali fruit the quota is not applied. Thus Somalia is in a good position to exploit its tariff advantage and increase its market share. If the 1970 share of 24% was regained this would amount to 72 000 t.

Somalfruit consider a 30% share to be the maximum, fearing reprisals from the multi-nationals. However, if a strong production base was developed in Somalia, its ACP status, 20% tariff advantage and lower shipping costs should enable Somali producers to survive strong commercial competition. The potential market therefore, is likely to be much higher and a realistic 50% share would amount to a market for 150 000 t/year of Somali fruit.

3.4 The Middle East Market

The rapidly expanding markets of Iran, Iraq and Syria have declined abruptly in recent years and only token amounts are now imported. In an attempt to encourage local production of fruit and vegetables, the Yemen Arab Republic banned all imports in 1984. At the same time the Saudi Arabian and Gulf states have experienced a rapid expansion, peaking at 287 000 t in 1981 and then levelling off at the present 250 000 to 260 000 t/year, due to the economic recession resulting from the fall in oil prices. Details are given in Table 3.4.

TABLE 3.4

Middle Eastern Banana Imports from 1981 to 1984 ('000 tonnes)

	1981	1982	1983	1984
Saudi Arabia	138.0	145.7	147.0	154.0
Kuwait	30.0	35.0	35.0	12.3
Yemen Arab Republic	29.5	32.5	17.6	-
Oman	35.0	15.0	16.0	16.0
Bahrain/Qatar/UAE	21.1	5.0	5.0	-
Others	34.0	31.0	30.0	30.0
Total	287.6	264.2	250.6	258.3

Source: FAO

The major suppliers to this market are the Philippines, which distribute via the east coast of Saudi Arabia through Dammam, and Central and South America, and Somalia which distributes through Jeddah. Somalia enjoys a considerable advantage due to her proximity to this market (see Table 3.5), although this advantage would be greater if the FOB price was not higher than its competitors. In 1984 Somalia had a share of about 11% of the Middle East market.

TABLE 3.5

Comparative Costs of Bananas in the Saudi Arabian Market (US$ per tonne in 1984)

	FOB	Freight and insurance	CIF
Ecuador	262	246	508
Philippines	277	168	445
Central America	289	219	508
Somalia	305	117	422

Source: FAO.

It has been suggested that the Saudi Arabian market will accept fruit of a lower quality than the European markets. Although this may have been true in the past, increasing competition from other suppliers has meant that high quality fruit is now readily available and quality is more important.

A vital factor in increasing market share would therefore be the regular supply of very high quality fruit. A reduction in FOB prices, through improved efficiency and management, could possibly see Somalia's market share increase to over 25% over the next few years, to around 65 000 t. Like the Italian market, the potential is greater if supplies are reliable, quality very high and the price highly competitive.

3.5 The Local Market

The local market absorbs the fruit rejected for export. In 1985, 45 321 t were exported from 5 121 ha. Assuming an export reject rate of 50% (harvested yield 18 t/ha) and allowing 5% for wastage, a reasonable estimation of the local market could be 43 000 t, equivalent to a per capita consumption of 8.6 kg. Somalfruit has plans to build a cool store in Mogadishu and promote a special pack for the domestic market. Unlike many producing nations the banana is not a prime source of carbohydrate in Somalia and the consumption is unlikely to rise greatly. It therefore appears unlikely that a market exists for fruit other than export rejects.

3.6 Market Projections

Somalfruit forecasts that exports should reach 100 000 t by 1988, this expansion to be achieved by annual increases in yields and improved productivity. Analysis of the Italian and Arabian markets suggests that a combined market exists for some 137 000 t (72 000 t and 65 000 t respectively), and that an opportunity exists for an even greater share if high quality fruit could be produced at a competitive FOB price.

The present record of expansion demonstrates that a national growth rate of 500 ha of bananas per year can be sustained. Assuming this growth rate and an increase in yields due to improved management, it is predicted that exports can increase to 137 000 t by 1993, as shown in Table 3.6. Thereafter market penetration would become increasingly more difficult. With Somalia's competitive position in the Middle East market and preferential status in the Italian Market and with improved productivity resulting in lower FOB prices, it would be realistic to assume a potential market share of 50% in Saudi Arabia and 30% in Italy. This would mean an export market for over 225 000 t. If the current annual growth rate of 500 ha continued until 1996, and thereafter there was a declining rate of expansion coupled with an improvement in export yields to 20 t/ha, this export target could be easily achieved by 2005 (see Table 3.6).

TABLE 3.6

Possible Future Exports and Areas of Production

	Banana area (ha)	Export (t)	Target export yield (t/ha)
1986	5 800	60 000(1)	10.3
1987	6 300	70 000(1)	11.1
1988	6 800	100 000(1)	14.7
1993	9 300	137 000	14.7
1996	10 800	162 000	15.0
2005	13 300	225 000	16.9

Source: (1) Somalfruit 1986 to 1988.
Own calculations

Under these assumptions and allowing for wastage, 80 000 t of fruit would be available as export rejects onto the local market by 2005. If the current per capita consumption remains constant this fruit would be absorbed by the increased population.

The market potential for increasing production in the Lower Juba depends partly on the future rate of expansion in the Shebelle, where output may also grow substantially. Banana areas in these two regions in 1984 to 1986 are shown in Table 3.7.

TABLE 3.7

Net Cropped Areas of Bananas

Year	Juba (ha)	Shebelle (ha)	Total (ha)
1984	2 571	1 921	4 492
1985	2 010	3 111	5 121
1986 (August)	2 276	3 564	5 840

Source: Somalfruit.

Flooding in the Jamaame district in 1985 adversely affected development in the Lower Juba but, despite this, the national area of bananas rose at an annual rate of 449 ha over the past 3 years, due to the increased area in the Shebelle. Further expansion in the latter area may, however, be made difficult by the increasing problems of water shortage in the low flow season. Even if the Shebelle was to reach its historical maximum area of 5 700 ha under banana, there would appear to be sufficient market potential in the Lower Juba valley for at least 7 000 to 8 000 ha, more than three times the current area of 2 276 ha. The maximum banana area in production achieved in the past was 5 075 ha. Even if the existing private sector was to expand sufficiently to match this figure, this would still leave 2 000 to 3 000 ha available for smallholder development.

CHAPTER 4

SMALLHOLDER BANANA PRODUCTION

4.1 Introduction

Smallholder farming would be a new development in banana production in Somalia but experience in other countries suggests that, if well organised and managed, the production of export bananas by smallholders can be very successful. In the Windward Islands, for example, 18 229 farmers with an average of less than 1 ha each farm 14 112 ha of rainfed bananas and supply 50% of the United Kingdom's banana imports.

4.2 Smallholder Attitudes

Smallholders' enthusiasm for banana growing will be essential for success and will depend on their willingness to grow cash crops in general and bananas in particular.

With the liberalisation of trading, allowing private merchants to purchase crops at market prices and the increased prices offered by the State run trading organisations such as ADC and Somaltex, smallholders appear now to be keen on producing cash crops. This is confirmed by the management staff of the large state farms such as the Juba Sugar Project which reports increased difficulty in recruiting labour, because its labour force finds it more profitable to farm on their own. Likewise the Mogambo project is receiving many requests for irrigated farms.

Smallholders and villagers interviewed on field visits showed a willingness to grow bananas, although they all considered the banana to be a plantation crop requiring at least 30 ha. This is no doubt due to the fact that the banana is not a native crop in Somalia and is not used as a major source of carbohydrate, as is the case in the humid tropics; there is thus no experience of its production even as a backyard crop. The only experience in banana growing the farmers have is that of working as labourers in the plantations. Farmers interviewed at Homboy considered bananas to be a very profitable and attractive crop but one that requires too much investment and skill for a smallholder to grow. With good organisation and supporting services this constraint could, however, be overcome.

Others interviewed considered food crops for home consumption such as maize to be just as important as the production of cash crops for sale. Banana as a smallholder crop may therefore require a change in farmers' attitudes, as well as extensive training of farmers in crop production.

4.3 Problems Facing Smallholder Banana Production

Most of the farmland in the Lower Juba valley, apart from the banana estates, is cultivated by smallholders farming between 0.5 and 5 ha, growing mainly rainfed maize, sesame, sorghum and cotton. Many of these smallholders in or near the banana zone may be casual workers in the banana plantations and may be familiar with some of their operations; many, when approached on field interviews, showed a willingness to be involved in banana production as producers. There are, however, major problems facing smallholder involvement in export production, namely:

Agronomic

The banana is a highly perishable perennial crop harvested throughout the year and demanding a high level of horticultural skill in such operations as pruning, cultivation, fertiliser and pesticide applications and, more importantly, in adapting banana culture to the sub-optimal conditions prevailing in the Lower Juba valley. This will require skills and expertise unlikely to be found in subsistance farmers.

Social

The crop demands a discipline involving a daily commitment and harvesting demands adhering to predetermined production schedules. Most of these smallholders have experience in annual cropping with lengthy periods of inactivity and may adapt slowly to the work discipline required.

Commercial

The supply of inputs, credit and the marketing of produce is handled by Somalfruit. The company willingly support a scheme to involve smallholders but are naturally unwilling to become involved in the administration of a multitude of small accounts. The administrative and logistical problems of servicing the marketing requirements of many smallholders make it essential for these growers to have a central packing station, the organisation of which would be beyond the capabilities of existing smallholders.

Financial

Establishment and first year production costs are very high, probably well beyond the means of existing smallholders. Short-term credit will have to be provided for basic inputs along with the supply of disease-free planting material to enable them to commence production.

In view of the problems facing smallholders it is envisaged that the only practical way for their involvement in a highly competitive export industry is the creation of an autonomous authority responsible for smallholders. The Authority should work as a commercial unit and be large enough to warrant a centralised packing operation. The key to its success, however, will be the employment of a highly competent technical and administrative management providing credit, inputs and planting material together with training and extension services.

4.4 The Potential for Smallholder Production

Market prospects for smallholder banana development appear to be attractive, provided that fruit quality is kept high enough to meet export standards.

The area for future banana development in the Lower Juba valley to meet the forecasted export market, approximately 8 000 ha net, was described in Chapter 2. Assuming that the historic maximum of 5 075 ha net was fully developed by existing farmers there remains some 3 000 ha which could be developed by smallholders. The net areas do not include the fallowed areas. The area of fallow is related to the longevity of the banana crop, that is, with the normal crop life in the area, of 3 years, the minimum fallow would be 25%. Increasing the life to 4 years would reduce the necessary fallow to 20%. With the present banana life of 3 years, a total farm area of about 6 800 ha would be needed by existing farmers in order to have 5 075 ha of bananas in production.

This effectively means that only about 1 000 to 2 000 ha of the original banana land in the Lower Juba Valley would be available for smallholder production and additional banana land would have to be developed. As there is little suitable land not yet farmed by existing banana farmers adjacent to the river such development would require extensive irrigation works.

With 3 260 ha identified in the Homboy area as being suitable for banana (HTS 1980) there is potential for smallholder development along with the expansion of existing farms after the construction of the Bardheere dam.

4.5 Crop Agronomy

4.5.1 Agronomy and Production Systems

Smallholder production would differ little from the current production methods employed in the Lower Juba valley. Each smallholder would be encouraged to take pride in his holding and the standard of each labour intensive operation is likely to be higher than the equivalent work carried out by hired labour on a plantation. With reasonable care and management together with the supply of clean disease-free planting material the life of the crop should be at least 4 years. As experience is gained over the years the better smallholders may be able to extend the life to a maximum of 6 years. The soils in the area prevent the possibility of a longer life.

(a) Cultivars and Planting Material

The existing cultivars Poyo, Guande Naine and Valey would be grown and the planting material would be raised in a central nursery using the methods described in detail in Chapter 5 for the production of disease-free suckers.

Large maiden suckers of similar age and 15 to 20 cm in diameter would be chosen and the pseudostem cut back to within 25 cm of the corm. All the young buds with the exception of two should be left in such a manner that they are on opposite sides of the sucker. Selection and treatment in this way will ensure uniformity, growth and fruit production.

(b) Land Preparation

As the banana responds to high levels of organic matter in the soil, the burning of trash would be avoided - ideally a green manure such as Pueraria phaseoloides or Crotalaria juncea would be grown prior to the banana crop.

The purpose of land preparation is to control weeds and provide an open, well aerated soil structure. New land would have a high residual weed seed population which would be activated by irrigation, and perennial weeds, such as Cynodon dactylon (couch grass), have to be eliminated as the roots of this weed would adversely compete with the banana roots. The recommended cultivations involved in the initial land preparation are described in Chapter 7, Section 7.3. After the removal of an old banana crop, the land would be ploughed, either with a mould board plough or chisel plough and disced in preparation for the crops for home consumption. In preparation of the next banana crop the land would be ploughed and disced prior to forming irrigation furrows using a 'V' ridger. Land levelling may be required prior to the preparation of a new banana crop.

(c) Planting

Holes 30 cm deep would be dug in the furrows using the local hoe, a yambo, 150 g of di-ammonium phosphate (DAP 20% N 50% P_2O_5) and 30 g of Furadan would be placed in the hole prior to planting the sucker. Irrigation would then be applied immediately.

The sucker should grow rapidly and after 4 to 6 weeks the heart growth should be stopped by cutting back all the emerging side suckers except the strongest one which would be retained for the plant crop.

(d) Pruning

Pruning aims at maintaining a balance between yield and growth and to achieve this only one follower should be allowed every 4 to 5 months. Ideally the follower should be ready to shoot a flower when the plant crop is cut for harvesting. This rarely works in practice but the aim should be to produce three ratoon crops a year. Regular removal of unwanted suckers diminishes internal competition within the stool so that bigger bunches of better quality fruit are produced.

The system of the mother plant crop, followed by the 'daughter' ratoon should be adopted. The third ratoon would be the follower of the daughter and not the mother. These ratoons would be selected on a rotating basis and not in a line, otherwise the original spacing would be quickly disrupted. After the third ratoon, sucker development may be delayed for unknown physiological reasons and two compound suckers would be left at this stage, one of which would not be propagated further.

Pruning would be carried out routinely every 8 weeks and great care taken in removing the suckers using the yambo or machete.

(e) Weed Control

Weed control during the first year of growth is critical. Once the crop is established the dense canopy of leaves will give adequate control with only occasional spot weeding necessary. Provided the early weed growth is contained, mechanical cultivation should not be necessary and regular hand weeding would give sufficient control. Herbicides are not recommended for smallholder use as they require precise application and there is some practical evidence that their use may reduce crop vigour.

(f) Irrigation

At about 6 months after planting, when the roots have started penetrating the rows, a wide furrow would be made using a wide 'V' ridge down the centre of the row to form the final irrigation furrow. This operation also has the effect of earthing up the pseudostem thereby improving anchorage and stability in the wind. About 100 mm gross of water would be applied at an average frequency of 10 to 15 days depending on the season.

(g) Nutrition

The regular application of fertiliser containing the major crop nutrients, nitrogen, phosphorous and potassium would have to be applied on the soils found in the Lower Juba valley in order to achieve the maximum growth, bunch size and yield. Nitrogen is known to give significant and economic responses on most soils and the recommended fertiliser application is shown in Table 4.1.

TABLE 4.1

Annual NPK Requirements in kg/ha

	Quantity qt/ha	N	P_2O_5	K_2O
Recommendations: 1st year				
Urea	7	322	-	-
DAP	3	60	150	-
NPK	6	90	42	144
Total	16	472	192	144
Years 2 to 4				
Urea	9	414	-	-
DAP	-	-	-	-
NPK	9	135	63	216
Total	18	549	63	216

Ideally magnesium should be added at the rate of about 100 kg MgO per hectare to prevent the disorder 'Le bleu' - a blueish mottling on the underside of the petioles and midribs of the leaves.

(h) Pest and Disease Control

The major pests are burrowing nematode (Radapholus similis) and the banana weevil (borer) (Cosmopolites sordidus). The prime method of control would be in using planting material that has been heated in water at 60°C for 20 minutes and regular application of Furadan (Carbofuran), the chemical being used at the time of the study. The dangers of reliance on this chemical have been discussed in Chapter 2. However, if it were used the recommended application would be 120 kg/ha.

Sigatoka (Mycosphaerella musicola) and black sigatoka (Mycosphaerella fijiensis) are not prevalent in the area and regular control measures appear unnecessary. However, as the disease can be devastating in wet humid conditions, occasional spraying with crop oil and fungicides such as TBZ (Thiabendazole), Maneb or Benlate (Benomyl), may be necessary. Smallholders could do this by using a motorised knapsack sprayer but as the appearance of the disease is likely to be of national importance an industry-wide aerial spraying programme, arranged by Somalfruit, through the Locust Control Unit in Kenya, would no doubt be put into effect.

The recommendations for ground spraying are:

TBZ (Thiabendazole) at 125 g active ingredient per ha
Benlate (Benomyl) at 125 g active ingredient per ha

4.5.2 Cropping Patterns

With good husbandry and management the life of the banana crop produced by smallholders is likely to be over 4 years. Following this the land should be rested for at least one year to control the build-up of the burrowing nematode (Radapholus similis) which cannot survive in the soil in the absence of banana tissue for more than 3 months. Crops for home consumption, such as maize, sesame and vegetables could be grown on this land.

A smallholder starting production and lacking experience in banana culture would be advised to stagger production by planting 20% of the holding each year over a period of 4 years, the remaining 20% being used for other crops. Planted this way, the work load would increase as the smallholder gains in experience and full production would be achieved in the fourth year, thereafter a continuous supply of bananas would be produced, providing a regular monthly income. A proposed cropping schedule is presented in Figure 4.1.

Ideally a fallow or green manure cover crop should precede the banana crop, however, the smallholder would also require an area for the production of crops for home consumption. Provided that the choice of crops does not include crops likely to be injurious to the banana, such as watermelon, a carrier of cucumber mosaic virus, these could be cultivated on the fallowed area.

4.5.3 Yields

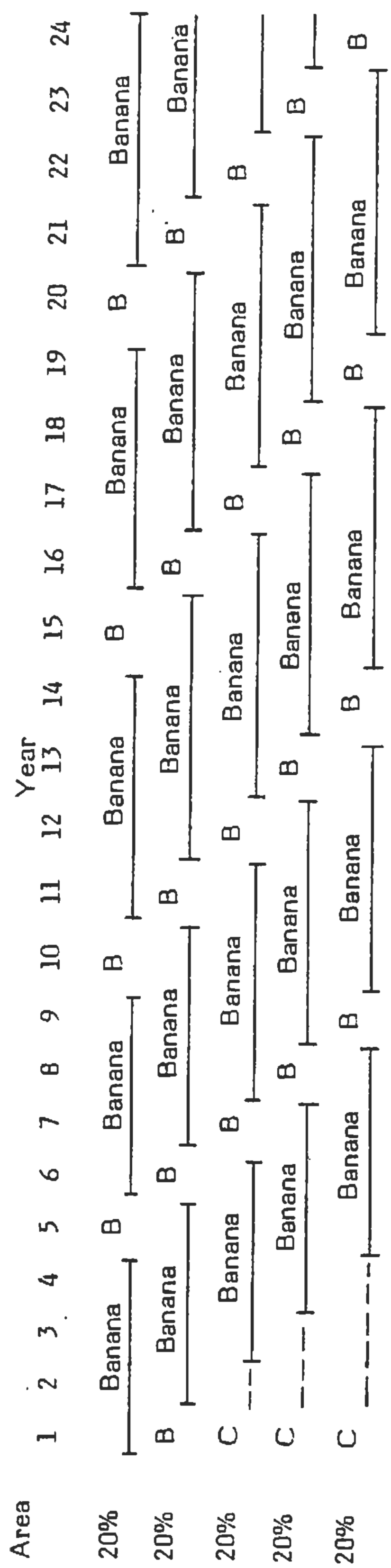
The best managed farms in the Juba valley produce average yields of 28 t/ha. It is unlikely, however, that a smallholder would achieve such yields in the first few years of production because of his inexperience, even with the guidance of experienced management. An average yield of 20 t/ha of export fruit and 5 t of fruit suitable for local markets is more realistic.

During the first year production tends to be cyclic, with the plant crop, i.e. the mother plant, producing over a short period followed by a gap in production whilst the first ratoon crop develops. Thereafter, because the following ratoons do not grow and develop evenly, harvesting and therefore cropping, becomes more regular. As the crop life is relatively short, yields in the fourth year would show a decline and the quality would naturally decline with age. The likely yield pattern for a 20 t/ha crop is shown as follows:

	Year 1 (t)	Year 2 (t)	Year 3 (t)	Year 4 (t)	Total (t)	4 year average (t/ha)
Export	10	26	24	20	80	20
Local	2	4	6	8	20	5

Figure 4.1

Cropping Programme for Smallholder Bananas



Notes: B = Break crop - Crops for home consumption,

C = Fallow or cover crop, i.e. *Pueraria phaseoloides*.

4.5.4 Water Requirements

Water requirements for banana farms are discussed in detail in Annex 1. Assuming a cropping pattern of banana (160%), maize (20%) and sesame (20%) then the net requirement in the peak month (December) is 157 mm. Taking a field efficiency of 0.50, then the gross requirement at the head of the watercourse is 314 mm per month.

4.6 Machinery Requirements

Banana production is labour intensive with machinery requirements limited to initial cultivations and post-harvest transportation. Smallholders, by definition, are unlikely to justify the purchase of equipment and land preparation is therefore likely to be undertaken by contractors or a smallholder scheme managing authority. The equipment could be hired from Somalfruit or through the government agency ONAT.

The basic operations are ploughing, discing and preparing furrows, and the machinery requirement and times are as in Table 4.2.

TABLE 4.2

Machinery Requirements for Smallholder Production

Operation	Machine	Equipment	Hours/ha
Levelling	Tractor 115 kW	Blade	16
Plough	Tractor(4)	Mould board plough or chisel plough	3 to 5
Disc(1)	Tractor(4)	Light discs	1.5
Plant furrow(2)	Tractor(4)	'V' ridger	9
Crop furrow(3)	Tractor(4)	'V' ridger	9
Haulage	Tractor(4)	Trailer	

Notes: (1) Two passes would be needed in most cases.
(2) The first planting per irrigation furrow.
(3) Earthing up and main irrigation furrow after 6 months.
(4) 60 kW minimum.

4.7 Harvest and Post-Harvest Operations

The fruit is ready for harvesting between 80 to 90 days from shooting when the girth of the middle finger of the second hand is 35 mm in diameter. Two adults would form the cutting team, one searching and cutting the selected pseudostem at a convenient height, about 1 m from the ground, the other guiding the bunch on to a fibreglass, padded headboard which is used to carry the cut bunch, on the head of the carrier, to a central point at the edge of the field. The bunch would be carefully placed on to an overhead wire supported on a simple framework, with the cut end facing downwards to prevent latex stain.

The hands would then be removed from the stem using a sharp knife, after first removing damaged and scarred fruit. Care would have to be taken to avoid latex dripping on to the fingers. The hands would then be dipped into an alum solution, a plastic pad placed over the cut crown to prevent latex stain and the hand placed carefully, crown downwards in a plastic field box lined with banana leaves.

Packing this way, in the field, reduces post-harvest losses considerably as well as simplifying both the final packhouse operations and recording individual growers production and quality.

The field boxes protect the fruit during transportation to the packhouse where the hands would be inspected, deflowered, washed, treated with benomyl, graded and packed in 'Somalita' cardboard boxes for collection by Somalfruit.

Fruit rejected for export would be sold to local merchants.

4.8 Holding Size and Labour Requirements

Previous studies indicate that the average family size is 5.5 persons with 2.1 adult males available for smallholder farming. Assuming an average working month of 26 days there would be 55 man-days per month available for the holding. In view of the fact that the smallholder will have a vested interest in maximising output from his holding these figures may be on the low side, but they allow sufficient reserve for unforeseen events.

The high labour inputs of cutting and harvesting bananas would be spread evenly over the year if the recommended planting schedule is adopted, due to the banana's natural tendency for each plant and ratoon crop to develop over a protracted period. The other cultural requirements can also be planned to give a relatively even monthly labour requirement.

A 2.5 ha holding, with 2 ha of bananas and 0.5 ha of annual crops, has a maximum monthly labour requirement of 57 man-days, as shown in Table 4.3, thus an average family has enough labour to farm a 2.5 ha holding.

As the standard banana crop is very valuable the smallholders should be encouraged to live on site, where practicable, thus protecting the farms from larceny, thereby avoiding the high cost of guarding the crop. Although the families' permanent houses would be in the project village, they could erect temporary dwellings in their fields to achieve this aim.

4.9 Costs and Returns

The benefits which are forecasted for the smallholders are substantial, details of which are given in Chapter 7. It has been predicted that the proposed 2.5 ha family holding would result in a farm gross margin of SoSh 556 300, as calculated in Section 7.11.

TABLE 4.3

Monthly Labour Requirements - 2.5 ha Smallholder Banana Farm
(man-days)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Bananas 2 ha:													
Establish (0.5 ha)	-	-	14	14	14	13	2	4	6	9	9	7	92
Crop maintenance (1.5 ha):													
Pruning	3	-	3	-	3	-	3	-	3	-	3	-	18
Leaf pruning	-	1	-	2	-	-	-	-	-	3	-	-	6
Weeding	6	-	-	6	-	-	6	-	-	6	-	-	24
Bagging(1)	3	3	3	3	3	3	3	3	3	3	3	3	36
Fertiliser	-	1.5	-	1.5	-	1.5	-	1.5	-	1.5	-	1.5	9
Nematicide	-	3	-	-	3	-	-	3	-	-	3	-	12
Hygiene	3	-	3	-	3	-	3	-	3	-	3	-	18
Irrigation	6	6	6	3	3	4	4	6	3	3	3	7	54
Harvesting	8	8.5	8	8.5	8	8.5	8	8.5	8	8.5	8	8.5	99
Packhouse duties	3	3	3	3	3	3	3	3	3	3	3	3	36
Total 2 ha	32	26	40	41	40	33	32	29	29	37	35	30	404
Annual Crops 0.5 ha:													
Maize (gu) (0.4 ha)	-	-	1	8	8	2	4	6	-	-	-	-	29
Sesame (der) (0.4 ha)	4	4	-	-	-	-	-	-	-	3	6	4	21
Vegetables (0.1 ha)	1	5	11	8	2	1	1	4	4	2	4	2	45
Total 0.5 ha	5	9	12	16	10	3	5	10	4	5	10	6	95
TOTAL 2.5 ha	37	35	52	57	50	36	37	39	33	42	45	36	499

Note: (1) See Section 7.3 for description.

Source: Consultant's estimates.

CHAPTER 5

ORGANISATION AND MANAGEMENT OF SMALLHOLDER BANANA PRODUCTION

5.1 Introduction

Three approaches to developing smallholders' farms have been considered:

- the mother farm/satellite farm concept;
- individual farmers organised as a commercial unit;
- co-operative development.

The mother farm concept was discarded as being impractical. There already exist large plantations which could contract smaller growers for their additional supplies. Somalfruit does this but for administrative and logistical reasons is unwilling to deal with a multitude of very small producers, all producing varying quantitites and qualities. Likewise, this could become a major problem with a mother farm and the resources might eventually be used for the development of the mother farm at the expense of the smallholders.

Unlike the majority of annual and tree crops the highly perishable banana responds to individual attention, the end product, being totally dependent upon pre- and post-harvest care. Thus, individual farmers' yields and grades will vary greatly. Once familiar with production, the farmer will become very aware of both yield and quality and their effect on his income. Organisation of farmers as a collective or co-operative, with pooled resources and pooled returns, may in theory result in the better growers influencing the poor ones to improve their production standards, but this assumes that each family will possess equal skills and attitudes, which is unlikely. With the very large differences in yield and quality that are likely, together with high monetary rewards, such a system is likely to cause resentment and ill-feeling. Thus, co-operatives are unlikely to work.

The best incentive would instead be to encourage the individual abilities of the smallholders. However, the smallholders are unlikely to develop on their own and would require central services such as machinery, irrigation, inputs, provision of credit, extension, training and packing.

5.2 Organisation

The best form of development would be by groups of smallholders collectively farming a commercial unit organised by an autonomous authority, with its own management providing the central services yet allowing the smallholders to operate as individual farmers under the control of the Authority.

Though autonomous, the Authority would be responsible to the Ministry running the Homboy Project, through the Project Management Unit (PMU) (see Annex 1, Section D), which would delegate full executive responsibility to the management to run the Authority as a commercial farm responsible for the hiring of staff and labour, fixing pay rates and determining input and management administrative charges to the smallholders.

The relationship between the Authority and Somalfruit would be very similar to other existing growers and Somalfruit would treat the Authority as another commercial grower in the area. Inputs, spares and fuel would be purchased from Somalfruit, which would also arrange for the collection and marketing of the export quality fruit. The export reject fruit would be sold directly to local traders.

As Somali banks are at present generally unwilling to extend credit to smallholders, credit would be provided by the Authority.

The views of the smallholders would be made known to the Authority through an association of smallholders, which would have regular meetings with the Authority, and through smallholders being represented on a scheme committee.

The proposed organisation structure is shown in Figure 5.1.

5.3 Management and Administration

5.3.1 Management

The success of a smallholder development scheme would depend on the efficient provision of management and central services such as:

Machinery:	tractors, equipment and fuel;
Irrigation:	supply, maintenance and distribution;
Credit:	organisation, supply, control and recovery;
Technical services:	provision of advisory and extension services;
Central packing:	organisation and management of the central packing station;
Administration:	handling and servicing smallholder trading accounts, procurement and the Authority's day-to-day administration.

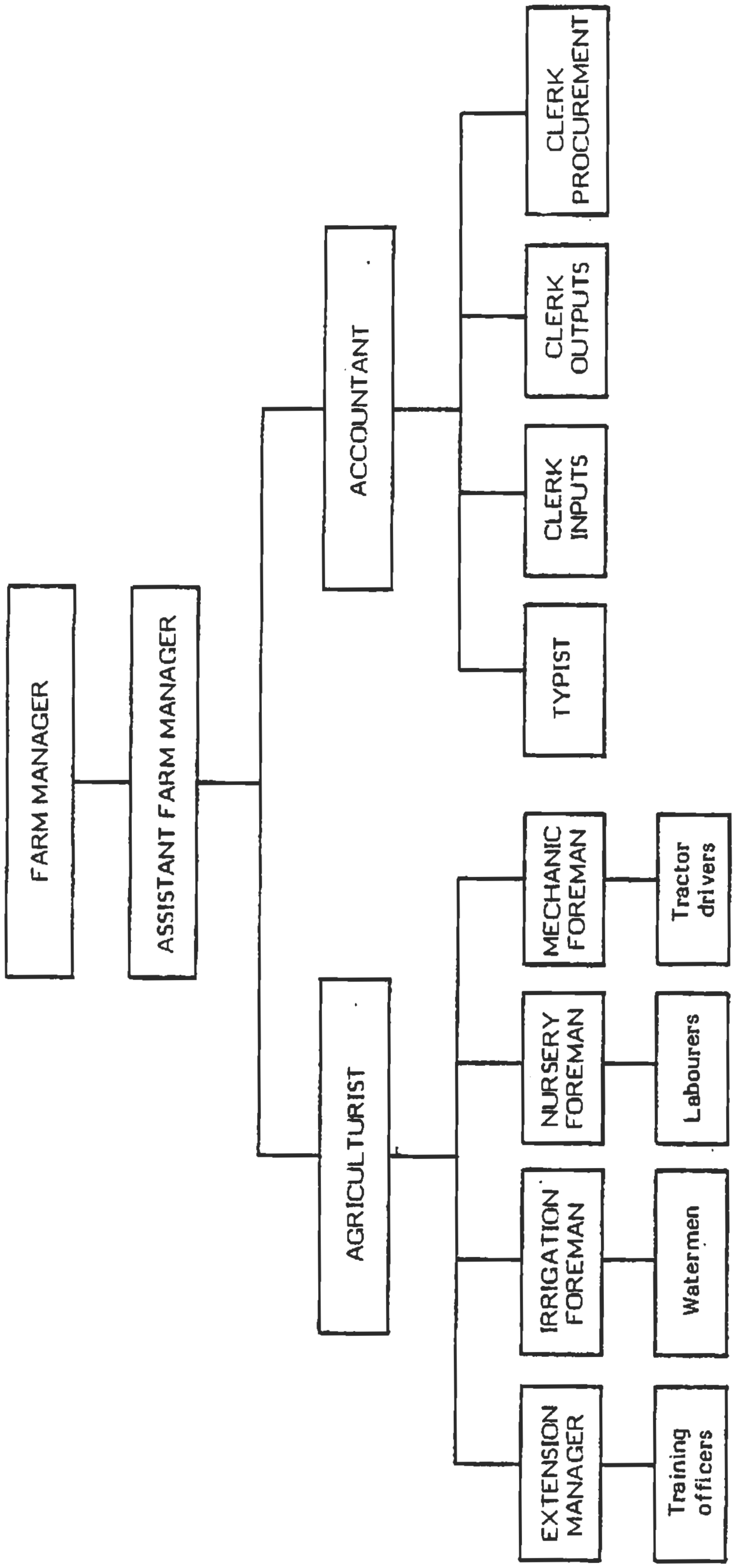
The managing Authority would be the link between Somalfruit and the smallholders. Somalfruit currently imports chemicals, fertilisers and fuel for re-sale to banana growers and also provides a machinery and repair service. The Authority would purchase these inputs from Somalfruit in bulk, for re-sale to the individual smallholders. It is considered most important for the scheme to be seen to operate as a commercial unit, with the smallholders competing on equal terms with existing farms. Any attempt at subsidising this particular group could cause ill-feeling within the existing industry and hinder integration.

The management structure would be based on four senior managers, the Farm Manager, Assistant Farm Manager, an Agriculturist and an Accountant as shown on Figure 5.1. The key issues facing the management would be the timely provision of inputs, credit control, water management and the maintenance of machinery.

The extremely valuable banana crop is greatly affected by these inputs. Erratic supply of fertilisers, chemicals and fuel or the failure of equipment because of a shortage of spares would result in smallholder disillusionment and the failure of the scheme.

Figure 5.1

Banana Farm Organisation, Management and Staffing Structure



5.3.2 Administration

Each individual smallholder would have a trading account held by the Authority, with services provided being debited at agreed commercial rates and the farmer being credited with sales revenues less an administrative charge.

The recording of individual production will be the major problem, as it is impractical for each grower's produce to be graded separately. Bunch weight could be recorded on delivery, identified by numbered headboards and an agreed deduction would be made for stem weights, together with an assessment of quality which would be reflected in the price returned to the individual. A better alternative, which we recommend, is to introduce the system of field boxing which is as yet untried in Somalia but is being increasingly used in other banana-producing countries. The system requires dehanding in the field and partial grading prior to packing in field boxes of about 30 kg. The fruit would be weighed on arrival at the packing plant and then assessed for quality.

Apart from enabling each farmer's produce to be graded separately and simplifying the packing operations, this system should significantly reduce post-harvest losses caused by transport and poor handling as well as enabling quality inspection and control to be carried out by the inspectors prior to collection.

All the export fruit would be sold through Somalfruit and the remainder would be sold to private merchants. The returns would be pooled and allocated to each individual smallholder according to his assessed grade-out and volume of output.

The smallholders would need to be involved in the development of the Authority and a mechanism needs to be provided for disputes and negotiations. It is therefore envisaged that the smallholders would be organised into associations, meeting regularly with the management. For the scheme to be successful, day-to-day management must, however, be in the hands of the Authority.

5.4 Technical and Extension Services

The Agriculturist would be responsible for irrigation management, equipment and tractors and an advisory team.

(a) Irrigation and Drainage

The management and supply of irrigation water to the smallholder and the maintenance of canals and main drains would be undertaken by the Authority through a senior irrigation farmer and field waterman. The distribution of water on the holding and the maintenance of the watercourses and field drains would be the total responsibility of the smallholder.

(b) Equipment and Machinery

Apart from basic land preparation, which would involve ploughing, discing and furrowing, the banana crop requires little mechanisation. When in full operation the central packing station would require four-wheel drive tractors with a minimum power of 75 hp for the collection of harvested fruit - a 600 ha holding would need about four tractors. However, their use would be limited to the 2 to 3 days in every 10 days when the packing station is operating. They would therefore be available for cultivation work and hired out to smallholders at appropriate rates. Heavy equipment and additional tractor power, if required, would be rented from either Somalfruit or ONAT.

(c) Advisory and Extension Services

The training of the smallholders in all aspects of banana production would be one of the main functions of the Authority and a team of training officers, one to every 100 smallholders, would be supervised by a training manager. Each training officer would be assisted by two field assistants and the entire team, apart from training smallholders, would also supervise harvesting and enforce fruit quality standards.

5.5 Central Nursery

One major advantage that such a development scheme would have at the start is 'virgin' land. To ensure a low level of disease as well as ensuring an adequate supply of planting material the Authority would establish a nursery for the production of disease-free stock. A 12 ha nursery would be sufficient for a 600 ha scheme.

The technique of producing nematode-free suckers, developed in Jamaica, is now well-established and is based on the discovery that heavy trimming of large maiden suckers, combined with heat treatment does not impair sprouting. The method is shown in Figure 5.2 and described below.

(a) Sucker Selection

Maiden suckers at least 20 cm in diameter are selected and cleaned of all roots, side suckers and debris and the pseudostem cut back to about 25 cm. The initial clearing should take place in the field where the suckers are taken to avoid the transfer of nematodes to the nursery.

(b) Trimming

The outer scales are removed along with any side buds and the head cut back to 5 to 10 cm, removing all discoloured tissue. Should there be any visual sign of weevil, such as small burrows or a staining indicating nematode, the sucker should be discarded at this stage. Treated corms must be at least 12 cm wide. One man can prepare about 500 suckers a day.

(c) Hot Water Treatment

The treated corms should be placed in hot water at 60°C for 20 minutes. In the field a metal tank of 120 cm x 60 cm x 60 cm can be used, heated by burners fed from a propane cylinder. The corms are placed in wire cages and lowered into the tank. Allowance must be made for the initial lowering of the water temperature when the corms are first placed into the water. In an eight-hour day 1 200 corms can be treated this way.

(d) Nematode Dip

Ideally, and to protect the corm from new infections, the heat-treated corm should be placed in a nematode dip. A suitable mix would be:

1 litre 'Nemagon' (75% EC)
250 ml 'Triton' (wetting agent)
in 500 litres of water

Figure 5.2

Stages in Clean Sucker Production 600 Ha Banana Farm

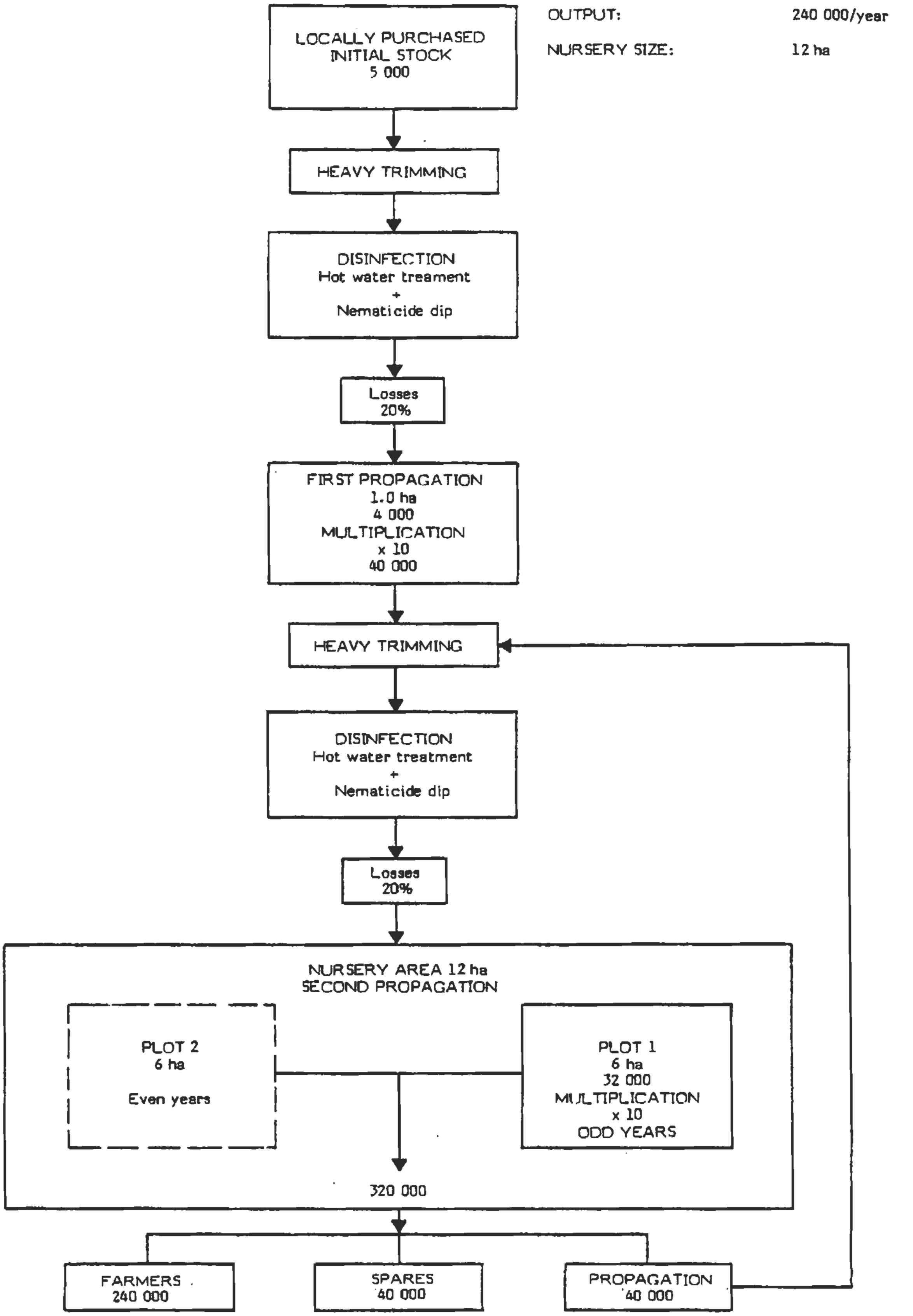
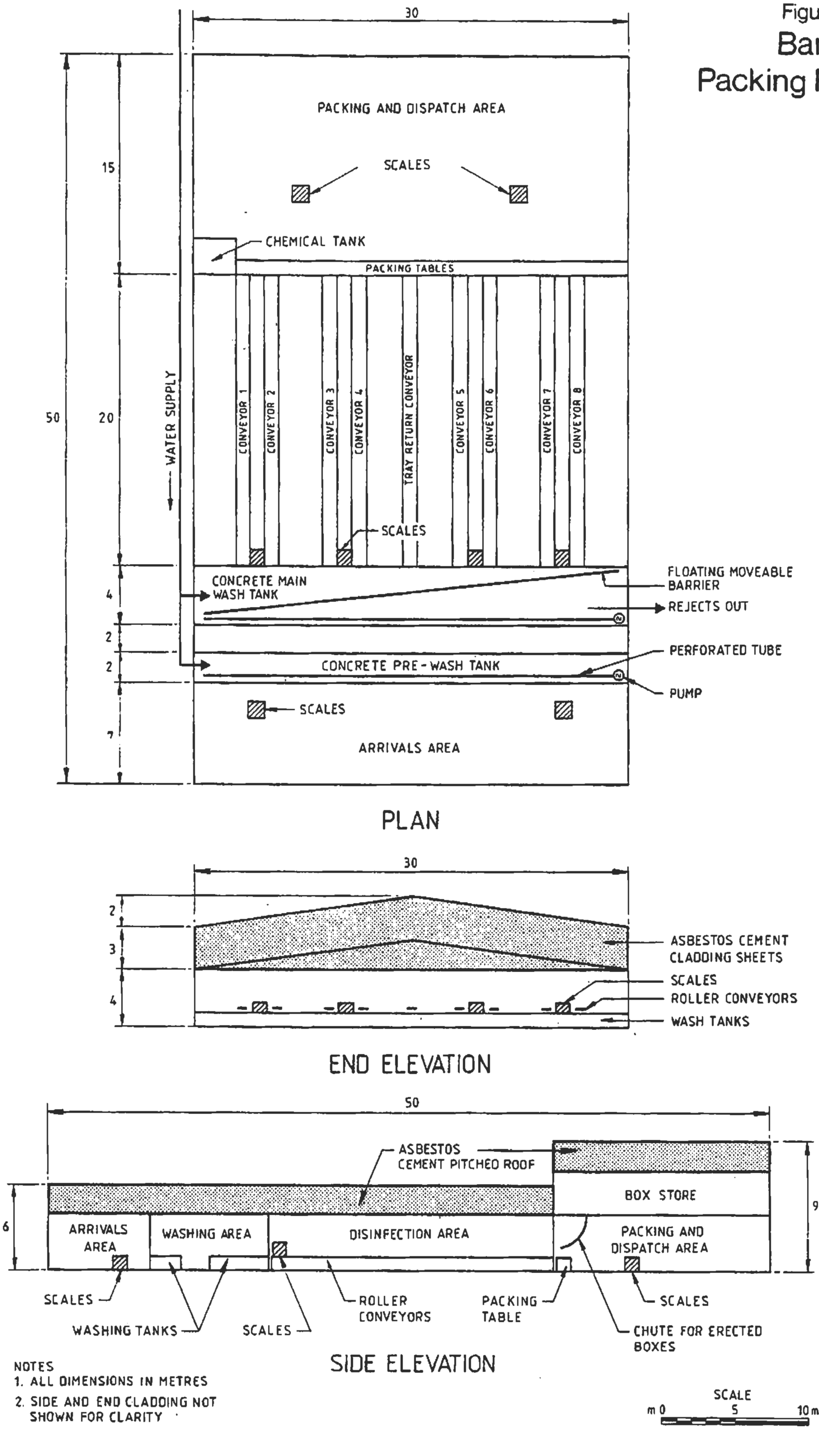


Figure 5.3 Banana Packing Plant



(e) Planting

The corms should be dried on a sterile surface such as a strip of polythene to prevent rotting. They are then planted in the nursery within 24 hours at a spacing of 1 m x 1 m.

The central heart growth should be retained and after six months growth suckers should be removed and treated as above, although such heavy trimming may not be necessary. They should then be planted in the main nursery.

This nursery comprises two equal plots, with planting rotated in alternate years. In the non-production year the plot would be planted with a green manure cover crop such as Pueraria phaseoloides.

5.6 Central Packing and Marketing

A central packing station would be provided by the Authority which would liaise with Somalfruit on harvesting and packing schedules. One such station (the layout of which is shown in Figure 5.3), would be required for each 500 to 600 ha and would have a throughput of 5 000 to 8 000 boxes per day. With picking staggered over a 3-day period those smallholders not picking would staff the packing plant. They would not be paid as the cost of their services would be reflected in higher returns paid for their produce. This arrangement would give the smallholders an insight into the quality standards required for export fruit and would give them an incentive to produce quality fruit as well as avoiding disputes over the rejected fruit.

A list of equipment for the packing station is given below.

Water tank A	2 m x 30 m waterproof concrete
Water tank B	4 m x 30 m waterproof concrete
Packing lines	8 x 20 m roller conveyor = 160 m 8 x 20 kg heavy duty platform scales
Return conveyor	1 x 20 m roller conveyor
Arrival	2 x 40 kg heavy duty platform scales
Dispatch	2 x 20 kg heavy duty platform scales
Equipment	4 x 1 hp continuous rated water pumps 2 x 30 m perforated (20 mm) tube plus fittings 1 water supply line plus 2 float valves 1 x 15 t fork lift truck 240 x plastic fruit trays 10 x knapsack sprayers 1 x 500 l chemical tank 800 fibreglass headboards
Generator	1
Borehole well pump	1

The sequence of packing would be as follows, if the field boxing technique is adopted:

(a) Arrival

The field boxes, each bearing the smallholder's number, would be stacked in the arrival bay out of the sun. They would be checked, weighed and assessed for quality and given a rating such as:

Grade A - less than 15% sub-standard
Grade B - less than 25% sub-standard
Grade C - less than 50% sub-standard
Grade D - more than 50% sub-standard

Individual smallholder's records would be maintained and the price paid to the smallholder would reflect his quality grade-out.

(b) Washing and Grading

The fingers would be deflowered and placed in the rapidly circulating water in the first tank, where most of the latex would be removed. Water circulation would be achieved by a water pump pumping the water through a perforated tube positioned at surface level along the length of the tank, with the jets spraying the water away from the loaders. This agitation causes the floating hands to move towards the opposite side of the tank where final selection and trimming takes place. Hands of less than four fingers being discarded along with the damaged or diseased fingers.

(c) Weighing

The selected fruit would then placed into a second identically equipped but larger wash tank from where the selected hands would be placed on plastic trays and weighed, to approximately 13.5 kg. This overweighing makes allowance for future shrinkage.

(d) Disinfection

The trays would pass on roller conveyors to the disinfection area where the fruit would be sprayed, by an operator using a high pressure knapsack sprayer, with a 2% Benomyl (Benlate) solution.

(e) Packing

The treated hands would then be packed into previously prepared cardboard boxes lined with a polythene bag, stapled and stacked, 80 boxes in layers of 10 onto one-tonne pallets for loading onto Somalfruit's lorries using a fork lift truck.

The graded and packed fruit would be sold to Somalfruit who would then be responsible for the marketing. The company, having previously arranged the scheduling of supplies with the Authority, would collect the produce from the Authority's packing plant and remit the agreed sale price to the Authority for each consignment.

The fruit rejected for export would be sold to market traders at the full market price. All the funds received by the Authority would be pooled and credited to the individual smallholder in proportion to his recorded yield and quality assessment, less an agreed service charge.

5.7 Research and Demonstration Farm

In addition to the nursery, a small demonstration farm would be provided to establish and demonstrate the effects of fertiliser treatments, pest and disease control and cultural practices. The provision of these services would have the added benefit of integrating the scheme with other banana growers in the area by providing much needed experimental data together with the possible sale of disease-free stock.

The farm would be identical in size to each smallholder holding of 2.5 ha and it would be the centre of the training and extension services.

A paid staff of three labourers would be required to operate the farm and the experimental programme would be organised by the Agriculturist with detailed recording undertaken by the extension staff.

Growing recommendations in Somalia have little or no scientific basis and field trials would be carried out on the demonstration farm to establish data on which sound cost effective recommendations could be based. A desirable programme would include the following trials:

(a) Fertiliser Trial

- the response to yield and cost effectiveness of varying rates and types of fertiliser;
- the effect of minor elements such as iron, manganese and boron on growth and yield.

(b) Pests and Diseases

- studies into the effect of different nematicides such as Mocap, Oxymil, Miral and Aldicarb;
- the development of weevil traps for cosmopolites control.

(c) Cultural Practices

- the development of techniques for early deflowering before the fingers develop;
- the assessment of the cost effectiveness of early removal of the male bud and false hand, that is, the last, usually incomplete hand.

(d) Irrigation

- establishment of guidelines for the correct interval between irrigations.

5.8 Input Supply and Credit

It is assumed that Somalfruit will continue to be the principal importer and supplier of fuel, fertiliser and chemicals for the banana industry. The Authority would purchase these inputs in bulk on behalf of the smallholder, debiting each account in accordance with the inputs supplied.

Somalfruit has also shown an interest in providing medium-term credit to established farmers for the purchase of equipment. This is at a fixed price, with no interest and is to be repaid over a fixed period of time. However, it is unwilling to provide short-term credit for inputs except in exceptional circumstances where such credit would be limited to about 3 weeks and deducted from a trading account. At present the banks offer facilities to established farmers only who are in production and are unwilling to provide credit to smallholders. Initial start-up credit would therefore have to be provided by the Authority.

Credit recovery would have to be strictly enforced and the accounting system would enable this to be done. There may, however, be exceptional cases where, for no fault of the smallholder, he is unable to repay, such as following a period of flooding. In these cases credit may be extended. Otherwise an inability to repay due to low productivity and poor quality, for example, would result in no further credit and could result in a possible loss of tenancy.

CHAPTER 6

SMALLHOLDER BANANA PRODUCTION ON THE HOMBOY PROJECT

6.1 The Project Area

The project area is located on the eastern side of the Juba river within the Jilib and Jamaame administration districts, extending to an area of 14 200 ha.

The soils are predominantly fine textured Shebelle alluvium deposited over the marine plain by flooding from the old Shebelle river channel. The narrow strip of irrigable soils, about 7 km wide, is bounded by the marine plain which is considered unsuitable for agriculture and is composed of fine textured poorly drained saline clays.

The area is susceptible to flooding and as a result settlement is restricted to the elevated areas. Homboy, with a population in 1979 of about 4 000, is the only village of any size, although there are a number of villages, such as Burgaan (population 1 500 in 1979) and Aminow (population 630 in 1979). There are in addition a number of small settlements and temporary camps established by nomads.

In 1979 some 25% of the area had been cleared for agriculture, mainly rainfed, and this area has since increased. The area is also important to the nomads as grazing for livestock.

The new Jilib/Golweyn surfaced road running to the north of the project area has improved access, but the tracks connecting Homboy with this road and the surfaced Jibil-Kismayo road are frequently impassable during the rainy season.

6.2 The Banana Areas

Bananas would be the main perennial crop grown on the Homboy site and they would be produced mainly on the 2 km wide strip of lighter soils adjacent to the old Shebelle river which runs through the centre of the project. Plate 4 in the Album of Drawings shows that the main area would be in the northern half of the site around the village of Homboy.

An area of 3 268 ha, identified by HTS in 1979, as Class II Sub-class IIW soils, suitable for perennial crop production is shown as mapping unit Sb, on the soil maps of the area. There are five almost contiguous areas of about 600 ha each, totalling 3 000 ha and these have been selected, each area close to one of the proposed villages. As the ideal banana farm size is between 500 and 700 ha, an area which fully justifies a central packing station, it is proposed that these areas are developed as five separate banana farms. Good vehicular access is needed to transport fruit from the packing stations and if these were sited in each village, no further road development would be required.

6.3 Banana Production

6.3.1 Cropping Patterns

Chapter 4 described in detail the crop agronomy and production systems considered suitable for smallholder banana production. Each of the five banana farms would comprise a group of smallholders each farming a holding of 2.5 ha with 2 ha in banana and 0.5 ha producing annual crops for home consumption.

With supervised management and the provision of disease-free stock the life of a banana planting should be at least 4 years. As the smallholder is unlikely to have any experience in banana production his introduction to this crop would have to be gradual, building up to the full area of 2 ha over a period of, say 4 years. This programme would also help to ensure regular supplies to the packing plant following establishment and after the first replanting.

The agronomic criteria applied to banana production would be:

- Weed Control: As the site is likely to be virgin soil the residual weed population activated by irrigation is likely to be very high. Perennial grass weeds such as Cynodon dactylon (couch grass) have to be eliminated, thus necessitating thorough cultivation and a fallow period prior to initial planting. Herbicides are not recommended, as experience shows that these can inhibit banana yield.

- Organic Matter: The banana responds to high levels of organic matter. Burning of existing trash should be avoided and, ideally, a green manure cover crop such as Pueraria or Crotalaria juncea (sun hemp) should be grown prior to establishment.

- Pest Control: Only disease-free planting material would be used, produced locally by the Authority which would be in a position to provide a regular supply of suckers.

  Details of a plant raising nursery are given in Chapter 5.

- Rotation: At least 12 months should elapse between banana crops, to reduce the build-up of burrowing nematode (Radopholus similis). Table 6.1 shows a suitable rotation programme.

TABLE 6.1

Cropping Schedule and Development-Production Smallholder Banana

	0.5 (ha)	0.5 (ha)	0.5 (ha)	0.5 (ha)	0.5 (ha)
Year 1	Banana	Pueraria	Maize	Maize	Maize/veg
Year 2	Banana	Banana	Pueraria	Maize	Maize/veg
Year 3	Banana	Banana	Banana	Pueraria	Maize/veg
Year 4	Banana	Banana	Banana	Banana	Pueraria
Year 5	Maize/veg	Banana	Banana	Banana	Banana
Year 6	Banana	Maize/veg	Banana	Banana	Banana
Year 7	Banana	Banana	Maize/veg	Banana	Banana
Year 8	Banana	Banana	Banana	Maize/veg	Banana
Year 9	Banana	Banana	Banana	Banana	Maize/veg
Year 10	etc.	etc.	etc.	etc.	etc.

All cover crops and annual subsistence crops would be chosen from those which do not harbour diseases common to banana, such as nematode and cucumber mosaic virus (CMV).

Der and gu season maize rotated with vegetables would be grown on the rested banana area for home consumption by the smallholder. In the first 2 years, during which the bananas are being developed, a large area of maize would be grown for cash.

6.3.2 Yields and Output

As the smallholder is likely to be inexperienced in banana production total yields are likely to be lower than on the best managed banana plantation, however, with good management average yields are likely to be in excess of 20 t/h with about 5 t produced for local markets. The yield pattern would be as described in Section 4.5.3 and the expected farm output would be as shown in Tables 6.2 and 6.3.

TABLE 6.2

Smallholder Export Production at Homboy (tonne)

Area	0.5 ha	0.5 ha	0.5 ha	0.5 ha	0.5 ha	Total
Year 1	5	-	-	-	-	5
Year 2	13	5	-	-	-	18
Year 3	12	13	5	-	-	30
Year 4	10	12	13	5	-	40
Year 5	-	10	12	13	5	40
Year 6	5	-	10	12	13	40
Year 7	13	5	-	10	12	40
	etc	etc	etc	etc	etc	etc

TABLE 6.3

Smallholder Local Production - Homboy (tonne)

Area	0.5 ha	0.5 ha	0.5 ha	0.5 ha	0.5 ha	Total
Year 1	1	-	-	-	-	1
Year 2	2	1	-	-	-	3
Year 3	3	2	1	-	-	6
Year 4	4	3	2	1	-	10
Year 5	-	4	3	21	1	10
Year 6	1	-	4	3	2	10
Year 7	2	1	-	4	3	10
	etc	etc	etc	etc	etc	etc

Full production would not be needed until the fourth year of production. The reasons for this are:

(1) Not all the 240 smallholders could be trained, settled and be in production at one time.

(2) The inexperienced smallholder would not be able to cope with planting and managing 2 ha from the start.

(3) Sufficient planting material would not be available.

(4) Phased planting would ensure a constant throughput of produce at the packing plant.

Each farm would be developed over a period of 3 years. The build-up of cropped area would be:

Year 1	-	Nursery and demonstration unit established.
Year 2	-	First 120 smallholders established.
Year 3	-	Final 120 smallholders established.

Phasing of the development over this period would enable the new smallholders to receive the maximum attention from the training and extension staff and developing the total area with phased plantings would allow a constant throughput of produce at the packing plant.

Planned output based on the proposed cropping plan is shown in Table 6.4.

TABLE 6.4

Farm Output (tonnes)

	Holdings	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Phase 1	1(1)	20	40	40	40	40	40
Phase 2	120	-	600	2 160	3 600	4 800	4 800
Phase 3	120	-	-	600	2 160	3 600	4 800
Total	241	20	640	2 800	5 800	8 440	9 640
Homboy	1 205	100	3 200	14 000	29 000	42 200	48 200

Note: (1) Demonstration farm.

The output from all the Homboy farms would be over 48 000 t a year providing over 20% of all the projected banana exports from Somalia.

6.3.3 Labour Requirements

Assuming a 26 day working month there would be 55 man-days per month available for the holding for the average family, as described in Section 4.8. The average monthly labour requirement is 42 man-days although the maximum monthly labour requirement is 57 man-days in April, as shown in Table 6.5.

TABLE 6.5

Monthly Labour Requirements - 2.5 ha Smallholder Banana Farm (man-days)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
Bananas:													
Establish bananas 0.5 ha			14	14	14	13	2	4	6	9	9	7	92
Crop maintenance and harvesting 1.5 ha	29	23	23	24	23	17	27	22	20	25	23	20	276
Packing	3	3	3	3	3	3	3	3	3	3	3	3	36
Total 2 ha	32	26	40	41	40	33	32	29	29	37	35	30	404
Annual crops:													
Maize/sesame veg. 0.5 ha	5	9	12	16	10	3	5	10	4	5	10	6	95
Total 2.5 ha	37	35	52	57	50	36	37	39	33	42	45	36	499

The banana packing plant would be staffed by the smallholders on a rotation system. Packing would take place over a 3-day harvesting period every 10 days to coincide with the scheduled arrival of the ships. At full production the packhouse will be processing 9 600 t a year or on average 88 t (7 000 boxes) a day. Eighty workers would be needed to man the plant, thus each smallholder would work one day at every harvest on packhouse duties, a total of 3 man-days each month, as shown in Table 6.5.

6.3.4 Machinery and Equipment

Smallholder machinery requirements are discussed in Chapter 4. If the smallholders were organised as a commercial farm as proposed in Section 6.4, the farm would require tractors and trailers for the transportation of produce from the fields to the central packing station.

At full capacity the packing plant would be processing 12 000 t of harvested fruit annually, producing 9 600 t of export fruit (assuming a reject rate of 20%) amounting to 768 000 cartons. Assuming that the ships continue to arrive at 10-day intervals and packing is carried out over 3 days, the daily throughput would be 111 t of harvested fruit, requiring 3 700 plastic field boxes. Assuming a 6 hour day, a delivery rate of 19t of bananas/hour to the packing station would be needed to maintain production. This would be achieved using 4 trailers and 4 tractors for haulage.

When not operating as harvest transport the tractors could plough approximately 3 ha per day or disc 6 ha per day. Once established, each smallholder would require 0.5 ha to be cultivated twice a year for his annual crops and 0.5 ha for the banana replanting. The timing of the banana replanting is not critical, unlike the cultivation for the annual crops. All the smallholders may require the tractor services for the latter at the same time, in which case 120 ha would need to be cultivated over as short a period as possible. Five tractors would be able to plough this area in 8 days and 4 tractors would disc it in 5 days, so no further tractor power would be needed on the farm apart from the occasional use of heavy plant, which would be hired from ONAT or Somalfruit.

It is envisaged that a commercial rate would be charged to the smallholder for this service.

Table 6.6 lists the machinery and equipment requirement for each farm and the total complement for the Homboy banana area.

TABLE 6.6

Machinery and Equipment Required for Homboy Banana Production

Type	Number per farm	Number for total area
Tractors	5	25
Trailers	4	20
Ploughs	5	25
Discs	4	20
UV sprayers(1)	8	40
Ridger	2	12

Note: (1) Only required if 'Sigatoka' outbreak occurs. Based on 10-day spray cycle and spraying 3 ha/d.

6.3.5 Spares and Maintenance

If tractors and pumps were purchased through Somalfruit then it should be in a position to supply spares from stock or from its well-equipped factory which manufactures spares at Araba. However, since consumable spares could be in short supply at times, the farm would maintain a stock of these and other essential spare parts. Maintenance, in general, is badly carried out in Somalia and this is probably a major reason for the unnecessarily high demand for spare parts. The farm management would ensure that correct maintenance is undertaken and smallholders would not be allowed to operate farm machinery and tractors.

6.3.6 Inputs

Each farm would have a nursery using the methods described in Chapter 5, Section 5.5. A total area of 120 ha or 20% would have to be replanted, requiring 240 000 suckers each year. The initial stock for cleaning would be 5 000, purchased from local farmers, and this would be multiplied up to the 240 000 annual requirement for each farm as follows:

Month 6-9 5 000→Disinfection → 20% losses→1st propagation x 10 → 40 000

Month 9-18 40 000→Disinfection → 20% losses→2nd propagation x 10 →320 000

Distribution: 320 000→Farmers 240 000→Spares 40 000→Propagation → 40 000

A total of 1 600 000 suckers would therefore be produced by the five Homboy banana farms to supply the annual demand for planting material. It is assumed that Somalfruit would continue as the principal supplier of inputs such as fuel, fertiliser and chemicals for the banana industry. Each farm trading as a separate commercial entity would purchase these in bulk from Somalfruit for resale to each smallholder, debiting each account in accordance with the inputs supplied. The annual farm needs together with the total requirements for the Homboy area are shown in Table 6.7.

6.4 Organisation and Management

The five farms would be run as independent farms within the management structure described in Annex 1.

The Deputy General Manager, with responsibility for bananas, of the Homboy management team would have overall responsibility for each of the five farms although these would be run as individual commercial farms within the scheme. He would be responsible for liaison with Somalfruit through which the fruit would be marketed and inputs for bananas purchased.

Each farm would have its own management team headed by the Farm Manager, his responsibilities would include:

- Input purchases and distribution
- Machinery
- Water management
- Farm services and training
- Farm nursery
- Packing
- Credit and financial control of smallholders' accounts.

In addition each farm will have an Assistant Farm Manager, an Agriculturist and a Farm Accountant. Each smallholder would be responsible for the management of his holding including irrigation and channel maintenance. Collectively the smallholders would form an association which would meet regularly with the farm management and also provide representatives on the project liaison committee.

Details of staffing and organisation and management are given in Annex 1 Section D. The large scale commercial production of export banana requires a high level of managerial and technical skill which can only be gained from extensive experience. For this reason for the first few years of establishment it is recommended that an expatriate Deputy General Manager is employed and he would train Somali managers to take over.

The Farm Manager would be supplied with an estate car, the other senior staff with 4-wheel drive pick-ups and the foremen and extension works with motorcycles.

TABLE 6.7

Annual Inputs

Type	Unit	Requirements - Homboy Banana Farms[4] Smallholder	Farm (240 smallholders)	Homboy (1 200 smallholders)
Fertiliser:				
Urea	tonne	1.7	408	2 040
DAP	tonne	0.15	36	180
NPK	tonne	1.65	396	1 980
Total	tonne	3.5	840	4 200
Chemical:				
Furadan	kg	240	57 600	288 000
Benlate[1]	kg	-	216	1 080
Fuel:				
Tractors[2]	litre			
Cultivations	litre		44 640	223 200
Transport	litre		32 400	162 500
Generator[3]	litre		68 616	343 080
Total fuel	litre		145 656	728 280
Materials:				
Plastic bags	each	6 000	1 440 000	7 200 000

Notes:

(1) For packhouse

(2) Based on 3 720 cultivation hours at 12 l/h
Based on 4 320 transport hours at 7.5 l/h

(3) For packhouse 108 days at high duty 12 l/ha at 6 h/day. For administration and housing 365 days at low duty 7.5 l/h at 24 h/day.

(4) No allowance for annual or cover crops.

6.5 Infrastructure and Facilities

One packing station is required per 600 ha of bananas, and thus five stations will be needed for the total banana area of 3 000 ha. These would be located at suitable locations in the banana areas, either at the villages or elsewhere so as to minimise distances from the banana fields and to be close to main access routes.

The banana packing stations, described in detail in Chapter 5, would be the headquarters for each farm. The packing station, 150 m x 50 m, would stand in a secure area sufficient to allow large articulated lorries room to manoeuvre. Each farm would require the following facilities:

- packing shed fully equipped - size 150 m x 50 m
- houses for management staff
- office/store building - size 10 m x 5 m
- borehole and water supply network for the packhouse
- generator and electrical supply.

An area of 15 ha would be required for the nursery which would supply the 240 000 suckers required annually by the smallholders, with a further 2.5 ha for the demonstration farm which would be the centre for the farmers' training and extension services.

The smallholder's families would live in the villages, described in Annex 1 although the smallholders would be encouraged to construct and inhabit temporary housing on the holdings to deter thieves.

6.6 Costs and Returns

Costs and returns for the banana farms at Homboy are discussed in Annex 1.

6.7 Phasing and Implementation

The development of Homboy banana production should ideally depend on the evaluation of the pilot scheme which will start banana production in 1996 as described in Chapter 7. The first land at Homboy becomes available in 1995, and there would therefore be a delay in the planting of bananas at Homboy of at least two years, with alternative crops (e.g. maize and sesame) grown in the intervening period. However due to their highly attractive economic returns this strategy is questionable and it may be better to plant bananas as soon as possible, even though no experience from the pilot farm will have been gained.

Adopting this programme, then full production would be achieved by 2001 as shown in Table 6.8. If it is decided to postpone bananas at Homboy until the pilot farm is well established, then a three year delay is envisaged and full production would be achieved by 2004.

TABLE 6.8

Banana Farm Development - Homboy

Year	Operation	Production (t)
1995	Nursery and demonstration farm established	
1996	First 120 smallholders established	20
1997	Second 120 smallholders established	640
1998	All farms commence production	2 800
1999-2000	Build-up of production	5 800 - 8 440
2001	Full production	9 640
Total output of the 5 farms		48 200

CHAPTER 7

THE 500 ha SMALLHOLDER PILOT SCHEME

7.1 Introduction

Unlike most banana producing countries, the banana is not grown as a backyard or smallholder crop for home or local consumption. The export crop has traditionally been grown as a plantation crop. There is therefore no experience in the country of smallholder production and their involvement in the highly specialised quality export market is obviously a major constraint.

Smallholder export production has been very successful in other banana producing countries such as the Ivory Coast and the Windward Islands but success can be attributed to a high level of organisation and managerial expertise provided, in the main, by the marketing companies which have an assured market and require guaranteed supplies. Somalfruit already has a storage production base and although it appears willing to support a smallholder scheme it is unwilling to be involved in organising a large smallholder scheme. This is mainly because of the administrative and logistical problems associated with handling many hundreds of very small accounts. Because of the commercial risks they are also unwilling to provide the necessary credit for inexperienced farmers.

The involvement of other marketing companies is unlikely because in a highly competitive export market dependent upon low FOB and shipping costs - and full loads are an essential prerequisite to attract ships - any competition to Somalfruit would have great difficulty establishing itself in Somalia.

In this respect a pilot scheme is considered necessary to identify the management, training and extension requirements for developing smallholder production prior to large scale implementation of a smallholder scheme.

The 500 ha pilot scheme is large by commercial standards and will require a very high standard of management, particularly during the early formative years, but the model proposed could readily be repeated as one of the many separate smallholder farms proposed for the Homboy scheme.

7.2 Location of the Pilot Area

The Terms of Reference call for the development of a 500 ha pilot area to test the feasibility of banana cultivation by smallholders. The area would be used as a model for smallholder development in the Lower Juba valley and also for the Homboy area.

The location of the pilot area within the Homboy command prior to the full development of Homboy would require the construction of the Homboy supply canal and flood protection works and would burden the pilot project with a high initial capital cost. It was therefore considered more practical to choose an area close to the Juba river which would require only a short supply canal and relatively low flood protection costs and be more representative of the existing banana areas.

The existing banana growing area occupies an almost continuous strip along both banks of the Juba river between Kamsuuma and Yoontoy. Parts of this area contain land which has been used for banana cultivation but is currently abandoned. However, there is evidence of a recent increase in banana planting and it is likely that many of these small abandoned areas will be replanted in the near future.

Suitable sites for the banana smallholder pilot area were examined with reference to the following criteria:

(i) The area should be in a single block of about 500 ha to make its management easier.

(ii) It should be close to the Juba river to limit the cost of the feeder canal.

(iii) In order to avoid a conflict of interests it should not include existing private banana areas.

(iv) It should be readily accessible from the main Kamsuuma to Kismayo road.

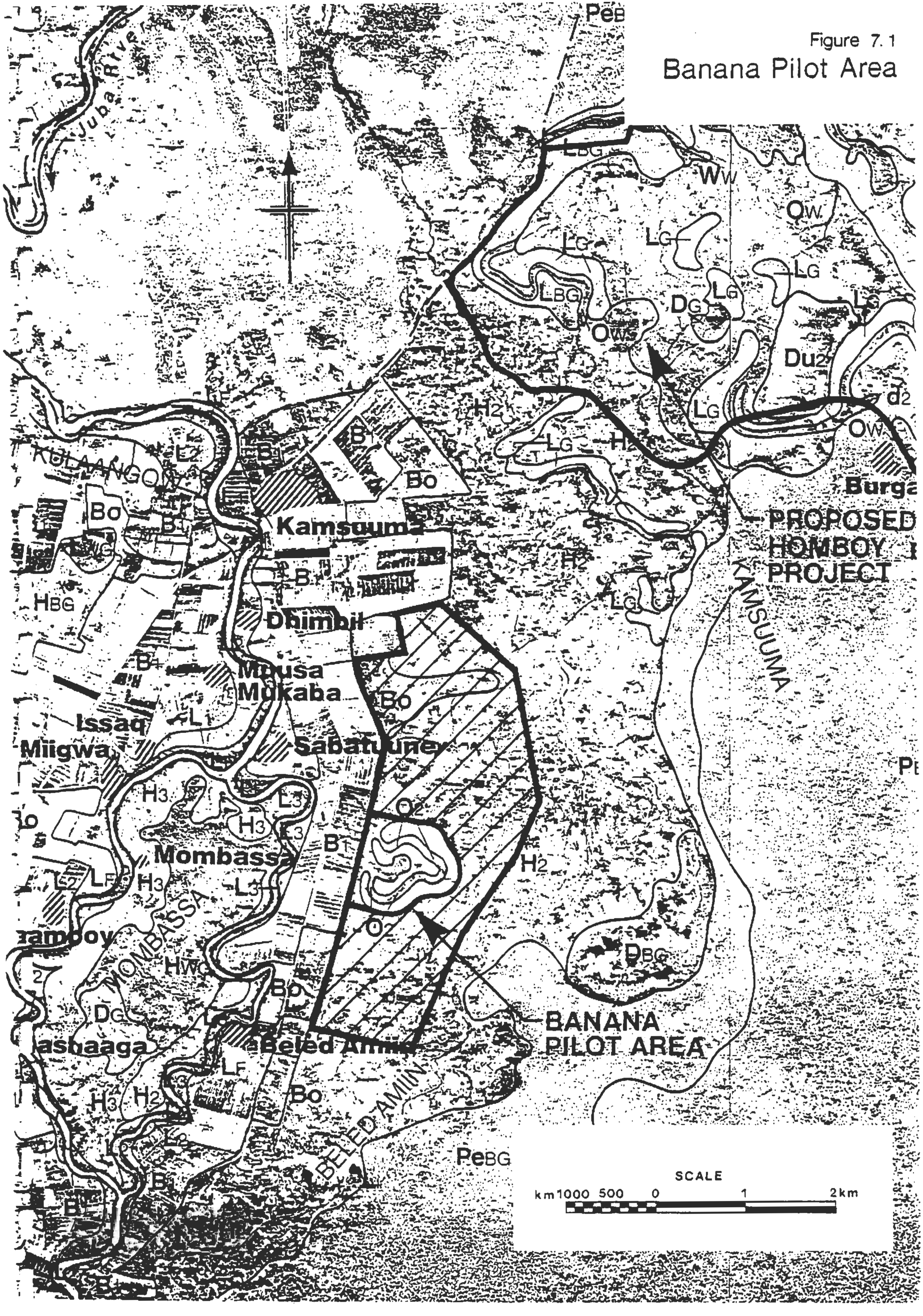
(v) The soils should be suitable for banana cultivation.

A strip of Class I soils have been identified along both banks of the river (Impresit 1979). The choice of suitable areas to meet the above criteria is limited by existing banana plantations, the proposed Stage II southern extension of the Juba sugar project and Phase II of the Mogambo project. However, two areas on the left bank of the river were provisionally identified as suitable for the Pilot area, one immediately south of Kamsuuma and the second some 6 km south of Jamaame. The USBR team is currently carrying out a land classification of the Juba valley and their preliminary mapping shows the area south of Jamaame classified as Class 4R(1) - suitable only for paddy rice cultivation, whereas the Kamsuuma area is shown as Class 2S and is considered suitable for banana cultivation.

The Kamsuuma pilot area (Figure 7.1) is the only area to meet all the criteria for the smallholder banana pilot farm. The area lies outside the flood protection bunds of the existing Romana farm and has virtually all been cleared of bush. About 60% of the area is farmed as rainfed agriculture by small farmers. However, the Romana farm has a lease for the area under the 1975 Land Registration Law, although it has carried out no development works in the area and has no immediate plans to do so. Under the Registration Law, the rights of registered farmers cease should the State require the land and the farmer automatically loses the right to the land if he fails to use it for a period of 2 years.

Flows in the Juba river are at a critically low level in the period from January to April. At current levels of abstraction there are shortages of supply in at least 1 out of every 2 years for five consecutive 5-day periods. The period of insufficient flow increases to some 60 days in 1 year in 5. The present expansion of the banana areas and small irrigation areas in the valley will only make the situation worse in the pre-Bardheere period. It would not, therefore, be prudent to implement the smallholder pilot farm prior to the construction of Bardheere dam, particularly since the smallholder farming system can only be fairly assessed if under optimum growing conditions.

Figure 7.1
Banana Pilot Area



We have completed a topographical survey of the pilot area near Kamsuuma together with a survey of the main canal alignment, and details are shown in Plate Nr 54 in the Album of Drawings.

There are a number of villages close to the area, the main ones being:

- Kamsuuma
- Beled Amin
- Sabatuune
- Burgaan
- Weshaag
- Moofa

There are about 765 families living in the immediate area according to RMR survey in 1984 and with the expected rate of population growth this could increase to 1 190 families by 1995.

About 50% of the land in the area is cleared for cultivation. Where rainfed agriculture is carried out the principal crops are cotton, maize and sesame.

There is a good unsurfaced road from Kamsuuma to Sabatuune providing easy access to the area.

Water for the pilot area would be supplied from a pumping station on the Juba river just upstream of the village of Sabatuune. The supply canal would cross about 1 km of existing banana plantations before entering the pilot area where it would split into two distributary canals. The irrigation and drainage system would be similar to that proposed for the Homboy area. Irrigation would be based on a 25 ha net water-course unit, 20 such units being required to give an area of 500 ha net (approximately 600 ha gross). A bund would be required around the eastern edge of the area to protect against flooding. Surface drainage would be achieved by a network of open drains which would drain under new eastern bund and into an existing natural drainage channel which discharges into the Juba river. Further details of the engineering works are given in Section 7.6.

7.3 Banana Production

It is important to establish windbreaks, such as Casuarina, on the farm to prevent damage to the plants. Ideally these would be planted in rows 50 m apart running east-west through the farm.

The production of bananas in the pilot scheme would be along the lines discussed in detail in Chapter 4.

Each smallholder farm would be 2.5 ha of which 2 ha would be in bananas and the remaining 0.5 ha would produce annual crops for home consumption such as maize, sesame and vegetables.

With inexperienced smallholders it is felt that a gradual introduction to the cultivation of the crop be desirable and it is recommended that the holding be divided into five equal units of 0.5 ha, with each unit planted successionally with banana over a period of 4 years. With a 4-year production cycle each smallholding would have bananas at 1 year, 2 year, 3 year and 4 years old along with the 0.5 ha of annual crops. This staggered planting not only allows more effective training and an even work load but also provides continuity of production so important for export planning and packhouse management.

Cultivations

For an area just bush cleared, the sequence of cultivations following the civil works and land levelling would be as follows:

(i) Deep Rip Ploughing

This operation would require a crawler tractor of 120 hp and would break up the hard compacted soil caused by the heavy earthmoving equipment.

(ii) Irrigation

The area would be flood irrigated to encourage the germination of weed seeds.

(iii) Ploughing

As soon as the soil is in a workable state, the area would be ploughed so as to bury the germinating seeds. The operation would also expose more roots of perennial weeds which would be killed off in the following fallow.

(iv) Fallow

The ploughed land would be fallowed for at least three months so as to kill off the weeds, especially perennial weeds such as couch grass, by drought.

(v) Discing

This operation would provide a seed bed for the cover and green manure crop.

(vi) Cover and Green Manure Crop

Either Pueraria phaseoloides or Crotolaria juncea (sun hemp) could be broadcasted as a cover and green manure crop.

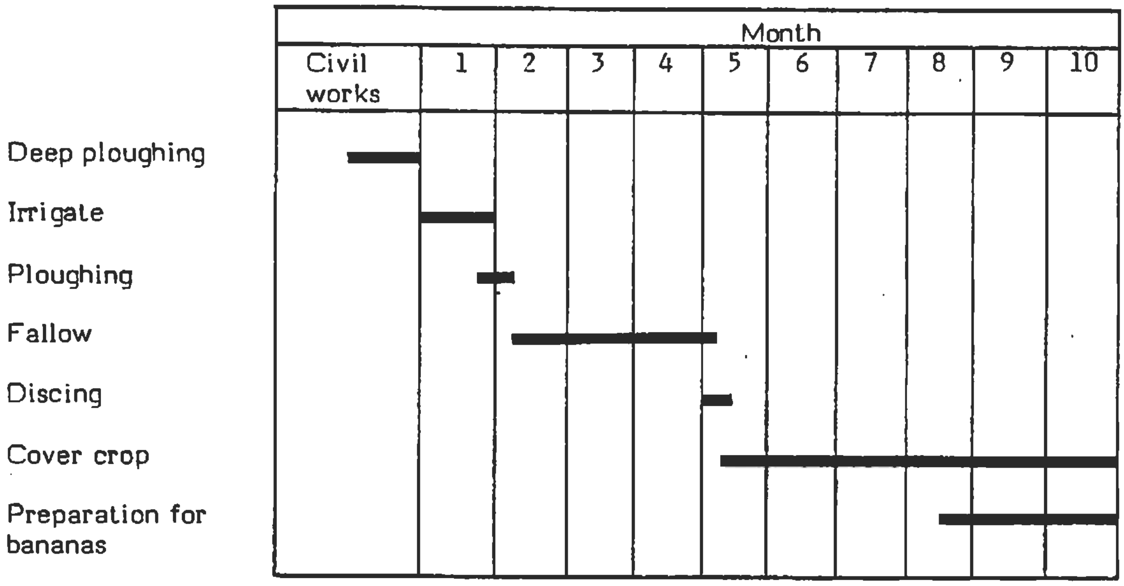
(vii) Preparation for Bananas

The cover and green manure crop would be ploughed in after 7 to 8 weeks, the land disced and 'V' furrows formed 2.5 m apart in preparation for planting the new stock of banana plants.

The timetable for these operations is shown in Table 7.1.

TABLE 7.1

Programme for Initial Cultivations



After the removal of an old banana crop the land would be ploughed, with either a mould board plough or chisel plough, and disced in preparation for the annual crops for home consumption. Land levelling may be needed prior to the next banana crop.

Planting Material

The nursery will require 10 ha to supply the 200 000 suckers needed annually by the smallholders. A demonstration and experimental farm would be established on 2.5 ha.

The disease and nematode free suckers would be produced as described in Chapter 5 by immersing in water heated to 60°C for 20 minutes, heavy trimming and disinfecting with nematicide. The nursery would be in full production 18 months from establishment.

Cultivars

The cultivars Poyo, Valey and Guande Naine would be grown. These are the three most widely grown banana cultivars throughout the main banana growing countries, and accepted on the world markets. Poyo has been the main cultivar grown in Somalia for many years and stock of the other two was introduced in 1964, all three are known to produce well under the local conditions.

Planting

Strong maiden suckers, 20 cm in diameter, heavily trimmed, heat treated by immersing in water at 60°C for 20 minutes would be planted in dug holes, in the furrows drawn at 2.5 m centres, at a spacing of 2 m. The planting sequence would be:

- dig hole 30 cm x 15 cm with yambo
- place 150 g di-ammonium phosphate plus 30 g Furadan in each hole
- trim sucker pseudostem to 25 cm
- stand upright in hole
- firm soil around corm
- irrigate as soon as furrow planted.

Irrigation

It is important that the developing corm receives the correct amount of water: too much will cause rotting whilst too little will result in root damage. At this stage regular hand sampling will be needed and the soil maintained in a moist condition. As the roots develop and the new suckers emerge the water supply should be gradually increased. When the plants are 4 to 5 months old a second furrow would be drawn down the row between the plants, filling in the first plant furrow and earthing up the stems. This wider furrow would act as the main irrigation furrow and full planned irrigation would commence from this stage.

Pruning

Only one sucker would be retained from the planted maiden sucker and all the other emerging suckers would be removed together with the plant growth. The ideal tool for this job would be the yambo or machete removing the sucker cleanly from the corm. All the new developing suckers would be removed on a 45-day cycle, until the fifth month when one strong, vigorous sucker, called the follower, would be allowed to develop for the following ratoon crop. Further desuckering would then continue until the tenth month when a second follower is retained. The pruning and production cycle can be represented, as shown in Table 7.2.

TABLE 7.2

Production Cycle

Month:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Plant crop	P						F			H								
Ratoon 1					P						F			H				
Ratoon 2									P						F			H
Ratoon 3													P					

Notes: P = Planting
F = Flowering
H = Harvest

Actual production will vary as the natural development in practice is spread over a period of time; and, within one planting/harvesting for a whole field would be spread over 1 month to 6 weeks. During the second year onwards the development would become more uneven resulting in a regular weekly harvest. Leaf pruning would be limited to removing cleanly and close to the stem, any diseased leaves together with those likely to rub against the developing bunch.

Bagging

All developing bunches would be protected from rubbing, wind damage and dust by wrapping in a polythene bag, tied securely to the uppermost part of the stem with the lower part open to allow the bunch to breath.

Weeding

This operation is of vital importance and would be regularly carried out by hand using the yambo. When the plants are at full cover the dense canopy should provide adequate control and only occasional spot weeding would then be required.

Fertiliser

The recommended fertiliser requirements are shown in Table 7.3. These would be applied to the mature crop every 2 months.

TABLE 7.3

Fertiliser Applications (g/plant)

Fertiliser NPK%	Urea 46.0.0	DAP 20.50.0	Compound 15.7.24
At planting	-	150	-
4 months	80	-	-
5.5 months	-	-	100
7 months	180	-	-
8.5 months	-	-	100
10 months	100	-	-
11.5 months	-	-	100
Year 2 onwards	100	alternated with	100

This is equivalent to about 0.9 t/ha per year of both urea and NPK for the mature crop.

Pest and Disease Control

Nematode (Radopholus similis) and weevil (Cosmopolites sordidus) would be controlled by routine applications of Furadan at the rate of 120 g per plant per year in four equal applications of 30 g per plant.

Sigatoka (Mycosphaerella musicola) is uncommon in the Lower Juba valley and only spot control would be necessary. ULV spraying using a knapsack sprayer is recommended for this using about 20 l of spray per hectare. Alternating sprays is considered important to avoid resistant strains of Sigatoka from developing and suitable chemicals would include:

Imazalil	300 g of active ingredient plus 10 l spraying oil per hectare
Benomyl	125 g of active ingredient per ha
Thiabendazole (TBZ)	125 g of active ingredient per ha

In the event of Sigatoka appearing it is likely that a national aerial spraying programme would be instigated by Somalfruit.

Harvesting

The field packing system described in Chapters 4 and 5 would be introduced. It is well known that the bunch considerably increases in weight during the last 3 weeks from harvesting, reaching a maximum at about 84 days from shooting. Yields can be maximised, and rejects caused through underdeveloped fruit minimised, by recording the date of flowering and cutting during the twelth week. A system of colour tagging the stem at flowering and cutting off all plants with that colour 12 weeks later can speed up the harvesting and increase total yields. In practice only six strongly contrasting colours would be required, the same six can be repeated from week 7 to 12 as the difference would be clearly seen in bunch development. It is a system demanding good management in recording, but has many advantages, particularly for smallholders, such as:

- eliminating the sizing and measuring by calipers;
- speeding up selection;
- ensuring even and consistent finger and bunch size;
- increasing yields.

This would be one of the many management techniques developed on the pilot scheme which could have a significant benefit for the national industry. The harvested fruit would be dehanded in the field and boxed in 30 kg plastic boxes, for transportation to the central packing station.

Packing

The project will have its own packing plant site within the project area.

At full capacity the packing plant would be processing 10 000 t of harvested fruit annually and producing, assuming a reject rate of 20%, 8 000 t of export fruit equivalent to 640 000 export boxes containing 12.5 kg of bananas. Assuming that the ships continue to arrive at 10-day intervals and packing is carried out over 3 days, the daily throughput would be 95 t of harvested fruit, requiring 3 500 plastic field boxes. The hourly rate would be approximately 16 t assuming a 6 hour day. Four tonnes of fruit could be transported on a flat bed trailer, thus requiring four tractors and trailers to supply the plant.

The field boxed fruit, each box bearing the growers number would arrive at the arrival bay of the plant, and be offloaded, checked, weighed and assessed for quality. The sequence of grading and packing described in Chapter 5 can be summarised as follows:

(a) Arrival check, weighed and quality assessed, four grades awarded as:

A Less than 15% substandard
B Less than 25% substandard
C Less than 50% substandard
D More than 50% substandard

(b) First washing and grading.

(c) Second washing and final selection and sizing of hands.

(d) Weighing - overweight to 13.5 kg to allow for shrinkage during transportation to ensure a net weight of 12.5 kg at point of sale.

(e) Disinfection - 2% benoxyl solution at high pressure to prevent crown rot and disease infection.

(f) Packing - into a polythene bag lining as previously prepared and made-up cardboard box.

(g) Stapling and stacking for collection by Somalfruit.

Cropping Pattern

As explained earlier in this section it would be desirable for each smallholder to develop the production by planting 20% of the holding each year, thereby, increasing his production as experience is gained. In the first year he would plant 0.5 ha of banana, and grow green manure cover crops or annual crops on the remaining 2 ha. Each year he would increase his banana planting by 0.5 ha until year 4 when full production would be reached. In year 5 the first banana planting would be removed, fallowed and the area planted with crops for home consumption. The suitable cropping pattern described in Chapter 6 can be summarised as shown in Table 7.4.

TABLE 7.4

Cropping Pattern Smallholder Banana Crop (ha)

Year	Banana	Maize/sesame and vegetable	Cover crop
1	0.5	1.5	0.5
2	1.0	1.0	0.5
3	1.5	0.5	0.5
4	2.0	0.5	0
5+	2.0	0.5	0

Yields and Output

With good management, inputs and care average yields for each smallholding would be about 20 t/ha of export fruit and 5 t/ha of fruit rejected for export and sold locally. The yield from each 0.5 ha farm block will vary according to the age of the plantation and the pattern of production for an average 20 t/ha export crop has been shown in Table 6.2 and is summarised in Table 7.5.

TABLE 7.5

Estimated Annual Production from an Average 20 t/ha Export Crop for 2.5 ha Holding

	Annual production of banana from holding Export (t)	Local (t)
Build up of Bananas		
Year 1 (0.5 ha)	5	1
Year 2 (1.0 ha)	18	3
Year 3 (1.5 ha)	30	6
Year 4 onwards (2.0 ha)	40	10

The output for the pilot scheme is based on the proposed development discussed in Section 7.9. This assumes that it is impractical to establish and train all the smallholders in one year mainly due to the supply of planting material and the problems anticipated in thoroughly training inexperienced smallholders. In the first year the nursery and demonstration farm would be developed, followed by the establishment of the first 95 smallholders in the second year and the final 100 in the final year. The pilot scheme output would be as shown in Table 7.6

7.4 Machinery and Equipment

Machinery requirements would be low for smallholders because production only requires mechanisation for initial cultivation and for the transportation of the harvested fruit (see Chapter 4). It is also assumed that most of the maintenance work is done by hand, although one small hydraulic excavator has been included.

The transportation of harvested fruit would be the responsibility of the farm and with a maximum harvested output of 9 800 t four 4-wheel drive tractors, would be required. These would be sufficient to cultivate the 0.5 ha of annual crops as well as prepare for the 0.5 ha annual banana replanting on each smallholders' holding. A list of vehicles, tractors, and equipment, including the packing station equipment is shown in Table 7.7.

7.5 Organisation and Management

The proposed management structure for the 500 ha pilot farm would consist of an autonomous authority managing the farm as a commercial unit. The Authority would come under the Ministry of Agriculture (MoA) but would have the power to administer its own budget. The Authority would be headed by a Farm Manager who would be directly responsible to the Director of Agriculture. The management structure of the Authority would be similar to the banana farms at Homboy (see Annex 1, Section D) comprising a Farm Manager, Assistant Farm Manager, Agriculturist and an Accountant, as shown in Figure 5.1, Annex 2.

The Authority would be given full responsibility for the hiring of staff and labour, fixing pay rates and determining input and management administrative charges to the smallholders. The views of the smallholders would be made known to the Authority through an association of smallholders, which would have regular meetings with the Authority, and through smallholders being represented on a scheme committee.

TABLE 7.6

Pilot Scheme Total Output (Tonnes)

		Year											
		1		2		3		4		5		6	
Phase	Holdings	Export	Local	Export	Local	Export	Local	Export	Local	Export	Local	Export	Local
1	1(1)	20	5	40	10	40	10	40	10	40	10	40	10
2	95(2)			475	95	1 710	285	2 850	570	3 800	950	3 800	950
3	100					500	100	1 800	300	3 000	600	4 000	1 000
TOTAL		20	5	515	105	2 250	395	4 690	880	6 840	1 560	7 840	1 960

Notes: (1) Demonstration farm - fully planted year 1.
(2) 10 ha required for nursery.

TABLE 7.7

Machinery and Equipment Requirements

Type	Number
Farm equipment	
Hydraulic excavator	1
Tractor 60 kW	2
Tractor 115 kW	2
Mould board plough	4
Discs	4
'V' ridger	4
Cultivator	2
Flat bed trailer	8
Field boxes	3 500
Knapsack sprayers	12
Land plane	2
Concrete mixer	1
Portable generator	1
Portable compressor	1
Workshop equipment	Set
Vehicles	
4 wheel drive estate	1
4 wheel drive pickup	3
Motor cycles	5
Packhouse Equipment	
Forklift truck 1.5 t	1
Water pumps 1 hp	4
Roller conveyors, 9 lines, 20 in.	180
20 kg scales, heavy duty	10
40 kg scales, heavy duty	240
Plastic fruit carriers	240
Fibreglass headboards (4 per smallholder)	800
Knapsack sprayers (1 per line, 2 spare)	10
Plastic chemical tank 500 t	1
Generator	1
Borehole well pump	1

The relationship between the Authority and Somalfruit would be very similar to other existing growers, and Somalfruit would treat the Authority as another commercial grower in the area. Inputs, spares and fuel would be purchased from Somalfruit, which would also arrange for the collection and marketing of the export quality fruit. The export reject fruit would be sold directly to local traders.

As Somalfruit banks are at present generally unwilling to extend credit to smallholders, credit would be provided by the Authority.

In the first 6 years the the post of Farm Manager would be staffed by a fully experienced expatriate who would train Somali managers to eventually take over. The responsibilities of the management team would be as follows:

- Farm Manager and Assistant Farm Manager - Responsible for the executive management of the scheme. Overall responsibility for finance, planning, staff, services and credit.

- Agriculturist - Responsible for agricultural services, water management, smallholder training, machinery, packing and marketing.

- Accountant - Responsible for financial services, smallholder accounts, input and credit control.

A training manager, supervised by the Agriculturist would have responsibility for the extension services and smallholder training.

Local junior staff would comprise training officers, foremen, clerks, tractor drivers and labourers. The requirement for labour is for central farm work only, such as maintenance of irrigation canals, water distribution and nursery work: the packing plant being staffed by the smallholders. A summary of the staffing requirements is given in Table 7.8.

TABLE 7.8

Management and Staffing Schedule

Grade	Status	Number
Farm manager	Expatriate	1
Assistant manager	Somali	1
Agriculturist	Somali	1
Assistant agriculturist	Somali	1
Accountant	Somali	1
Training officer	Somali	1
Extension worker	Somali	2
Irrigation foreman	Somali	2
Maintenance foreman	Somali	2
Nursery/packhouse foreman	Somali	1
Machinery foreman	Somali	1
Mechanics	Somali	2
Clerks	Somali	4
Drivers	Somali	9
Labourers	Somali	16
Ditch-riders	Somali	2

The Authority would employ 2 first class mechanic trained in pump and tractor maintenance and working under the close supervision of management. Smallholders would not use tractors or pumps.

A central packing facility would be provided and the management would liaise with Somalfruit on harvesting and packing schedules. With picking staggered over a 3-day period those smallholders not picking would staff the packing plant, which would have a throughput of 5 000 to 6 000 boxes per day during these 3 days. They would not be paid, the cost of their services would be reflected in higher returns paid for their produce. This arrangement would give the smallholders an insight into the quality standards required for export fruit and would give an incentive to quality production as well as avoiding disputes over the rejected fruit.

7.6 Engineering Works

7.6.1 General

The engineering works for the pilot farm comprise a pump station on the Juba river and a network of canals and drains and associated structures. In general the system is similar, both in design and operation, to the Homboy area described in Annex 1.

7.6.2 Bush Clearance and Land Levelling

Apart from small isolated areas, the pilot farm is clear of bush. Land levelling will however be required to achieve the recommended maximum allowable furrow slopes of 0.3% in the direction of irrigation and $\pm$0.3% across the direction of irrigation.

7.6.3 Irrigation System

Surface irrigation by furrows is proposed with a furrow spacing of 2.5 m and maximum length of 150 m. The peak water requirements are 5.1 mm/d net in December or 10.2 mm/d gross assuming a field efficiency of 0.50. The area is divided into twenty fields or watercourse units each of 25 ha net and a maximum of 2 units can be fed by a single watercourse of 60 l/s capacity. Part (12.5 ha) of one watercourse unit would be designated as the nursery (10 ha) and demonstration farm (2.5 ha).

The canal system is relatively short and could be operated during the daytime only and closed at night. However, as the farm is intended as a pilot project for smallholder banana development at Homboy, it is considered that the systems should be similar and thus continuous irrigation is proposed.

Water is supplied to the farm by a pump on the Juba river. The peak continuous requirement is 630 l/s, but to allow for short intervals for pump maintenance etc., throughout the day the specified pump capacity is 750 l/s against a static head of 3 m.

For this particular application where costs are to be kept to a minimum, the recommended type of installation is a diesel driven inclined axial flow pumpset. This assumes that electrical power is not available immediately - conversion to an electric drive pump could be carried out at a later date. The pump would be mounted at the end of a column pipe with its intake protected by an integral trash screen. The column pipe would be inclined into the river to give complete submergence of the pump, thus avoiding the need for any priming system. The diesel motor would be mounted on the river bank on a simple concrete slab. No permanent building is necessary, although a simple weather shield should be provided.

The pump discharges into the supply canal which is aligned across the existing banana plantations for about 1 km. A culvert will be required where the canal crosses the existing Kamsuuma/Bulo Mamu earth road. On entering the pilot farm area the supply canal splits into two distributary canals (B1 and B2) controlled by gated pipe head regulators. Watercourse offtakes from the distributary canals are through gated field outlets and water levels are controlled by fixed duckbill weir cross regulators. Typical structure drawings are shown on Plates 40 to 42.

The canals will be unlined and have bank top widths of 1 m and 4 m. A layout and canal longitudinal sections are shown on Plates 54 and 55.

7.6.4 Flood Protection

The area is currently subject to flooding from the Old Shebelle channel to the east and the existing banana plantations are already bunded to protect against this. Although the Homboy flood protection works will curtail the flooding to a large extent the timing cannot be guaranteed and there is also the danger of local runoff from the marine plain. It is therefore considered essential to bund the eastern perimeter of the project. The level of the bund should be consistent with the levels of the existing bund - approximately 15.0 m and 13.0 m at the northern and southern ends of the project respectively. The left bank of canal B1, raised as necessary, can be utilised to serve as the bund, thus requiring a separate bund only for about 1.5 km at the southern edge of the farm.

7.6.5 Drainage System

A drainage system is required to prevent excessive flooding of the cropped area after rain storms and also to collect excess irrigation water. The system is similar to that proposed for Homboy comprising shallow field drains discharging into main collector drains D1, D1.1 and D2. The design runoff is 1.5 l/s/ha net which assumes just over three days ponding on the fields following the 1 in 10 year rainfall event.

The drainage water will be discharged into the Old Shebelle meander channel which runs from north to south just to the east of the pilot farm. This will be achieved from main collector drains D1 and D2 passing under canal B1 and the flood bund as shown on Plate 54. It is anticipated that gravity flow should be possible for most of the year, but flap gates have been provided on the outlet culverts as a precaution against flood flows in the Old Shebelle channel.

7.6.6 Roads

Access to the farm is achieved by the existing earth road linking Kamsuuma and Bulo Mamu. Within the farm, earth roads are provided along one bank of all canals and drains.

7.7 Buildings and Infrastructure

The pilot farm would require the construction of a project village to house the smallholders. The new houses, for about 200 smallholder families, could be built as an extension to the existing village of Sabatuune. The houses would be built by the smallholders themselves on a self-help basis using materials provided by the project, similar to those proposed for the Homboy project.

The farm centre which contains the packing shed would be sited within the pilot farm area in a central position, on land which is unsuitable for banana production, so as to minimise the haulage distance between the fields and packing shed. The following buildings and facilities will be required:

- 7 Nr houses for senior staff;
- office/store building;
- small workshop;
- packing shed of approximately 1 500 m^2 plan area;
- covered area for farm machinery;
- generator and power distribution network for the houses, office and packing shed;
- borehole and water supply network for the houses and office;

7.8 Input Supply and Credit

It is assumed that Somalfruit would continue to be the major importer and supplier of imports such as fuel, fertiliser and chemicals to the banana industry. The Authority would purchase these from Somalfruit in bulk and re-sell to the smallholders, debiting each account in accordance with the import supplied plus an agreed fee for administration. The Authority would establish a nursery for the supply of disease and nematode-free suckers.

If tractors and pumps were purchased through Somalfruit then it should be in a position to supply spares from stock or from its well-equipped factory which manufactures spares at Araba. However, since consumable spares could be in short supply at times, the Authority would maintain a stock of these and other essential spare parts. Maintenance, in general, is badly carried out in Somalia and this is probably a major reason for the unnecessarily high demand for spare parts.

As Somalfruit and the Somali banks are unwilling at present to advance credit to smallholders, the Authority would provide the necessary capital and operational credit for the smallholders within the scheme. The credit would be recovered from the sales of bananas which would be administered by the Authority. All the returns from the packing stations output would be pooled and credited to each smallholder's account having first taken account of the assessed quality and charge of an administration fee.

7.9 Phasing and Implementation

Due to the water shortages likely in the jilaal season on the lower Juba it is considered imprudent to commence the scheme before the Bardheere dam is complete when this major constraint will be removed. An 12-month construction period is envisaged for the pilot farm commencing early 1994, this should ensure that cropping can commence on the completion of the dam in early 1995. The agricultural development would be phased over 3 years, the first phase, the establishment of the nursery and demonstration farm overlapping with the completion of civil works.

The build-up of the cropped areas is shown below:

1995 - Nursery and demonstration farm established

1996 - First 95 smallholders established

1997 - Final 100 smallholders established

The progressive build-up of the banana hectarage is shown in Table 7.9 and developed this way, full production would be achieved in the year 2000.

TABLE 7.9

Build up of Banana Area (ha)

Year	Holdings	Area developed in year					
		1995	1996	1997	1998	1999	2000
1995	1	2.5	2.5	2.5	2.5	2.5	2.5
1996	95		47.5	95	142.5	190	190
1997	100			50	100	150	200
Total		2.5	50	147.5	245	342.5	392.5

7.10 Costs of Engineering Works

Costs for the irrigation and drainage works, buildings and infrastructure have been calculated at early 1987 prices using the rates derived for the Homboy scheme as discussed in Annex 1.

The estimated costs have been drawn up in the form of Bills of Quantities and are presented in Tables 7.10 to 7.13.

TABLE 7.10

Bill Nr 1 - Land Preparation and Earthworks

Item	Unit	Rate (US$)	Quantity	Amount (US$ x 10^3)
1. Land levelling	ha	825	500	413
2. Excavate in canal and form canal embankments	m^3	2.75	500	1
3. Excavate in drains and form drain embankments	m^3	2.75	5 300	15
4. Excavate in drains and form canal embankments, haul > 200 m but < 1 000 m	m^3	3.20	3 300	11
5. Excavate in drains and form canal embankments, haul > 1 000 m but < 3 000 m	m^3	3.50	1 000	4
6. Excavate in borrow area and form canal and bund embankments, haul < 200 m	m^3	2.75	14 000	39
7. Excavate in borrow area and form canal and bund embankments, haul > 200 m but < 1 000 m	m^3	3.20	22 500	72
8. Excavate in borrow area and form canal and bund embankments, haul > 1 000 m but < 3 000 m	m^3	3.50	61 100	214
Sub-total				769
Contingencies (10%)				77
Total				846
Foreign exchange (85%)				719

TABLE 7.11

Bill Nr 2 - Canal and Drain Structures

Item	Unit	Rate (US$)	Quantity	Amount (US$ x 10^3)
1. Pump station	sum			60
2. Canal head regulator (1 x 0.75 m dia.)	Nr	11 200	1	11
3. Canal head regulator (1 x 0.45 m dia.)	Nr	6 600	1	7
4. Canal cross regulator, weir length 2.7 m	Nr	7 500	1	8
5. Canal cross regulator, weir length 4.3 m	Nr	8 500	2	17
6. Road culvert (1 x 0.9 m dia.)	Nr	11 000	1	11
7. Field outlets	Nr	2 500	11	28
8. Watercourse falls	Nr	500	5	3
9. Watercourse culvert	Nr	1 200	5	6
10. Drain junction culvert type 3 (1 x 1.2 m dia.)	Nr	17 700	1	18
11. Culvert type 2 with flap gates (1 x 0.75 m dia.)	Nr	10 000	2	20
12. Drain junction culvert type 1 (1 x 0.3 m dia.)	Nr	2 400	20	48
13 Field drain culvert	Nr	1 200	5	6
Sub-total				243
Contingencies (10%)				24
Total				267
Foreign exchange (65%)				174

TABLE 7.12

Bill Nr 3 - Buildings, Infrastructure and Equipment

Item	Unit	Rate (US$)	Quantity	Amount (US$ x 10^3)
1. Packing station (including services)	sum			250
2. House type B	Nr	60 000	2	120
3. House type C	Nr	30 000	5	150
4. Self-help houses	Nr	200	250	50
5. Workshop	Nr	20 000	1	20
6. Office/store	Nr	20 000	1	20
7. Wells	Nr	3 000	3	9
8. Furniture and equipment	sum			50
Sub-total				669
Contingencies (10%)				67
Total				736
Foreign exchange (70%)				515

TABLE 7.13

Summary of Costs

Bill Nr	Title	Total cost (USx10^3$)	Foreign exchange (US$ x 10^3)
1	Land Preparation and Earthworks	846	719
2	Canal and Drain Structures	267	174
3	Buildings, Infrastructure and Equipment	736	515
Totals		1 849	1 408

7.11 Project Costs and Returns

7.11.1 Project Costs

Table 7.17 summarises the estimated costs of establishing and operating the proposed banana pilot project. Capital costs will be incurred during the first year and include all civil works, land clearing and vehicles and equipment for the 500 ha irrigated area.

Project capital costs are divided into three components; civil works; agricultural machinery and implements, plant and vehicles; and credit.

The capital costs total US$ 2.65 million of which US$ 1.68 million, 63%, is required in foreign exchange.

Civil Works

The base costs of civil works including physical contingencies but excluding design and supervision will be US$ 1.84 million of which US$ 1.41, 76%, will be foreign exchange costs.

Machinery, Equipment, Plant and Vehicles

Machinery, plant and vehicle capital costs will total US$ 291 550 with a 95%, US$ 276 970 foreign exchange component. Requirements are low for smallholders because production only requires mechanisation for initial cultivation and for the transportation of the harvested fruit.

The transportation of harvested fruit would be the responsibility of the farm and with a maximum harvested output of 9 800 t only four tractors (2 x 60 kW plus 2 x 115 kW) would be required. These would be sufficient to cultivate the 0.5 ha of annual crops as well as prepare for the 0.5 ha annual banana replanting on each smallholders' holding. A list of vehicles, tractors, and equipment, including the packing station equipment is shown in Table 7.14.

Credit

The farmers selected for the pilot banana project will have few physical or financial resources. It is proposed therefore to establish a revolving credit fund to finance individual family's crop inputs during the establishment period

TABLE 7.14

Machinery and Equipment Requirements

Type	Number	Cost US$ '000 Unit	Total
Hydraulic excavator	1	35.00	35.00
Tractor 60 kW	2	18.23	36.46
Tractor 115 kW	2	22.06	44.12
Mould board plough	4	3.04	12.16
Discs	4	4.58	18.32
'V' ridger	4	1.09	4.36
Cultivator	2	2.20	4.40
Flat bed trailer	8	5.72	45.76
Field boxes	3 500		1.74
Knapsack sprayers	12	0.20	2.40
Landplane	12	12.09	24.18
Concrete mixer	1	0.50	0.50
Generator	1	0.80	0.80
Compressor	1	1.10	1.10
Workshop equipment	set	5.00	5.00
Vehicles			
4 wheel drive estate	1	15.22	15.22
4 wheel drive pickup	3	9.76	29.28
Motor cycles	5	2.15	10.75
TOTAL			291.55

Source: Consultants' estimates.

of their holding. The requirements have been calculated on the basis of providing for the costs of machinery operations, fertilisers and other agro-chemicals for the banana crop. Other crops; maize, sesame and the small area of vegetables to be grown by each family would be funded from their own resources. The requirements would be as shown below for each hectare of banana crop:

	US$/ha
Bananas	
Plant year	1 780
Years 2, 3 and 4	1 380

The credit fund capital requirements total, excluding contingencies, would be US$ 524 000 spread over project years 2 to 6 as follows (US$ '000):

Project year	1	2	3	4	5	6	Total
Credit fund capital requirements	-	85	138	105	84	112	524

The requirements are based on a 90% repayment level and an interest charge of 10% per year. The full costs, as described above, are met in the first plant and ratoon year of the area planted by each farmer thereafter. It has been assumed that there is a 20% reduction in the costs to be met by the fund. The project authority is therefore expected to encourage growers to meet these costs, after initial establishment, from their own resources as far as possible despite the usual tendency for farmers to take credit to release funds for other non-agricultural expenditure. The 20% annual reduction in an individuals uptake for each unit area, 0.5 ha, has been assumed to reflect this tendency.

Operating costs over the 6-year development period total US$ 900 000 of which foreign exchange is estimated at US$ 456 000, 51%. The components and annual expenditures are set out in Table 7.17.

Staff Costs

A breakdown of the cost of staff is given in Table 7.16. Expatriate assistance is confined to the Farm Manager who will be needed for the first 5 years. Local staff costs will rise from US$ 2 520 in year 1 to US$ 31 520 in subsequent years. Details of costs are given in the Homboy report, Annex 1, Section 7, and salaries are based upon those at the Juba Sugar Project. These are significantly higher than present government rates but are considered necessary to attract and retain the quality of staff needed. Unit costs for each man-year are also shown in the table at both financial and economic rates.

The economic rates are net of personal taxes for local staff (see Homboy report, Annex 1, Section 7). Expatriates are not expected to pay local taxes and the financial and economic costs are the same.

At financial prices, the cost of salaries and wages over the first 6 years will be US$ 312 000 of which US$ 145 000 will be as foreign exchange for the Farm Manager. Once established, this post will be taken over by the local Assistant Manager.

Vehicle and Plant Operating Costs are set out in Tables 7.15 at both financial and economic prices. The latter are adjusted for the higher forecast fuel prices and include provision for replacements including interest on the capital employed at a rate of 10%.

The financial costs will be US$ 45 000 from the second year and US$ 11 000 in year 1. The total 6-year development period cost is estimated at US$ 236 000 with a foreign exchange element of US$ 142 000 (60%). Farm machinery costs are included in the incremental crop benefits.

Pumping Costs

Pumping costs are estimated at US$ 48 000 from the second year at financial prices and US$ 53 490 at economic prices. As with other machinery costs, the latter includes provision for replacement, 10% interest on capital and for the higher fuel and lubricant prices (See Homboy Annex 1, Section F, Chapter 5).

Maintenance of buildings and packing shed equipment has been included at 1.5% of the original costs as shown in the cost summary table. Irrigation structures maintenance is included at 0.5% of the capital cost.

Miscellaneous costs are not broken down but have been included at 5% of all other operating costs. This includes the operation of the proposed planting material nursery.

Contingencies are included at 10% for physical contingencies and 6% per year compound for financial contingencies, as in the Homboy Study, Annex 1. These rates are applied to the total base costs and the financial contingencies are excluded from the economic cost flows.

The cost of operating the banana packing sheds are not included above. For example, the containers have been taken into account in the prices paid for the crop as described in the Homboy report - Annex 1.

7.11.2 Financial Benefits

The benefits which are forecast to individual farmer families are substantial. Details are given in Annex 1. The proposed 2.5 ha family holding would result in a farm gross margin of SoSh 556.300 each year made up as follows:

	Area (ha)	Gross income	(SoSh '000) Variable costs	Farm gross margin
Bananas				
Plant year	0.5	87.5	58.6	28.9
Years 2, 3 and 4 (average)	1.5	610.7	135.2	475.5
	2.0	698.2	193.8	504.4
Other crops				
Gu season:				
Maize	0.4	18.8	6.8	12.0
Vegetable	0.1	15.4	1.60	13.8
	0.5	34.2	8.4	25.8
Der season:				
Sesame	0.4	17.2	4.9	12.3
Vegetables	0.1	15.4	1.60	13.8
	0.5	32.6	6.5	26.1
Total		765.0	208.7	556.3

TABLE 7.15

Vehicle and Plant Operating Costs

Item	Nr	Financial Unit cost (US$)	Financial Total (US$ '000)	Economic Unit cost (US$)	Economic Total (US$ '000)
4 WD short wheel base	1	7 200	7.2	12 000	12.0
Pick-up 4WD	3	5 100	15.3	8 100	24.3
Motorcycles	5	1 600	8.0	2 300	11.5
Landplane	2	5 250	10.5	7 880	15.8
Concrete mixer	1	200	0.2	300	0.3
Generator	1	3 700	3.7	4 700	4.7
Compressor	1	200	0.2	300	0.3
Total			45.1		68.9

Source: Consultants' estimates.

TABLE 7.16

Annual Staff Costs

Designation	Grade	Nr	Unit cost (US$)	Total (US$ '000)	Unit cost (US$)	Total (US$ '000)
Farm Manager	Expat B	1	29 000	29.00	29 000	29.00
Assistant Manager	2	1	1 850	1.85	1 445	1.45
Agriculturist	3	1	1 610	1.61	1 260	1.26
Assistant Agriculturist	4	1	1 370	1.37	1 075	1.08
Accountant	2	1	1 850	1.85	1 445	1.45
Training Officer	4	1	1 370	1.37	1 075	1.08
Extension Officers	4	2	1 370	2.74	1 075	2.15
Irrigation Foremen	5	2	960	1.92	760	1.52
Maintenance Foremen	5	2	960	1.92	760	1.52
Nursery-packhouse Foreman	5	1	960	0.96	760	0.76
Machinery Foreman	5	1	960	0.96	760	0.76
Mechanics	5	2	960	1.92	760	1.52
Clerks	7	4	690	2.76	660	2.64
Drivers	7	9	690	6.21	660	5.94
Ditch riders		2	280	0.56	235	0.47
Labourers	Labour	16	220	3.52	190	3.04
Total years 1 to 5				60.52		55.64
Total year 6				31.52		26.64

Source: Consultants' estimates.

TABLE 7.17

Banana Pilot Project
Development and Operating Costs
(US$ '000)

	Project year 1	2	3	4	5	6	Total	Foreign exchange
Capital Costs								
Land preparation and earthworks	769	-	-	-	-	-	769	654
Canal and drain structures	243	-	-	-	-	-	243	158
Buildings, infra-structure and equipment	669	-	-	-	-	-	669	468
Machinery, plant and vehicles	292	-	-	-	-	-	292	277
Credit fund	-	85	138	105	84	112	524	-
Design and supervision	156	-	-	-	-	-	156	125
Total Capital Costs	2 129	85	138	105	84	112	2 653	1 682
Operating Costs								
Staff	36	61	61	61	61	32	312	145
Pumping	-	48	48	48	48	48	240	144
Vehicle and plant operation	11	45	45	45	45	45	236	142
Maintenance of buildings 1.5%	-	10	10	10	10	10	50	15
Structures 0.5%	-	4	4	4	4	4	20	6
Other miscellaneous costs 5%	2	8	8	8	8	8	42	6
Total Operating Costs	49	176	176	176	176	147	900	458
Total Base Costs	2 178	261	314	281	260	259	3 553	2 140
Contingencies								
- physical 10%	218	26	31	28	26	26	355	214
- financial 6% pa	-	16	39	54	68	88	265	160
TOTAL COSTS	2 396	303	384	363	354	373	4 173	2 514

This level of income would be achieved in a family's fourth year on the project.

As shown in Annex 1, present rainfed farming income is about SoSh 38 000 per family on a typical 2 ha holding.

Substantial increases will enable beneficiaries to meet the cost of operating the scheme's packing shed and other directly attributable costs, such as the operation and maintenance of the irrigation and drainage system, the upkeep of roads, etc. The level of these costs is given in Table 7.18 which also shows the resulting net farm income under the pilot project, which is estimated at SoSh 503 100 for each 2.5 ha holding when fully developed. As shown in Section 6.3.1 each holding will be developed over 4 years to give the individual crop areas set out earlier in this section.

TABLE 7.18

Banana Growers Net Farm Income
(SoSh '000/holding)

	Each 2.5 ha holding
Gross margin	556.3
Fixed costs:	
Pumping	22.2
Maintenance of civil works and irrigation structures	6.5
Vehicle and plant operation	20.8
Other costs	3.7
Total	53.2
Net farm income at full development	503.1

7.11.3 Economic Benefits

Table 7.21 sets out the crop benefits to the 500 ha pilot project. The benefits are based on the settlement of 195 families each with 2.5 ha. In year 2, 95 families will be established with the balance in the third year. This will utilise 487.5 ha, the balance of 12.5 ha is to be used as an area for project and crop specific demonstrations, including the proposed nursery for the production of disease-free banana planting material.

Details of the individual and 2.5 ha farm crop budgets are given in Annex 1. Table 7.19 summarises the farm gross margins at High and Low Price assumptions. At full development these will be US$ 10 741 (High Prices) and US$ 8 482 (Low Prices).

TABLE 7.19

Farm Gross Margins at Full Development at 'High ' and 'Low' Economic Prices (SoSh '000)

Crop	Area (ha)	Gross income	Variable costs	Gross margin (SoSh '000)	Gross margin (US$)
High Prices					
Banana:					
Year 1	0.5	151.0	93.0	58.0	644
Years 2, 3 and 4	1.5	1 048.9	232.9	816.0	9 067
Maize	0.4	34.8	13.6	21.2	236
Sesame	0.4	29.8	8.7	21.1	234
Vegetable	0.2	58.1	7.7	50.4	560
Total				966.7	10 741
Low Prices					
Banana:					
Year 1	0.5	127.5	93.0	34.5	383
Years 2, 3 and 4	1.5	886.7	232.9	653.8	7 264
Maize	0.4	29.8	13.6	16.2	180
Sesame	0.4	25.5	8.6	16.9	188
Vegetable	0.2	49.7	7.7	42.0	467
Total				763.4	8 482

Source: Consultants' estimates.

7.11.4 Build-up of Benefits

Smallholders will not immediately achieve the average gross margins. It has been assumed that they will be reached in the smallholders fourth year. The build-up is unlikely to take longer since cropping is based upon existing varieties and cultural practices and most smallholders will have had previous farming experience (see Annex 1). Other factors affecting the assumed rate of yield development include the level of Somalfruit's services relating to the procurement and distribution of essential crop inputs, e.g. seed fertilisers, etc.

The rate of average crop yield development assumed in the benefit calculations are given below, as a percentage of final yield:

	Year 1	2	3	4
Bananas	80	90	95	100
Other crops	60	75	90	100

The annual flow of farm incomes calculated on the basis of the above yield progressions is shown in Table 7.20. It has been assumed that the levels and costs of inputs are the same in each year.

TABLE 7.20

Build-up of Farm Incomes at 'Low' and 'High' Economic Prices as a Percentage of Final Incomes/year

Farm type	Year 1	2	3	4	5
Banana					
Low Price	10	35	65	95	100
High Price	15	40	70	95	100

Source: Consultants' estimates.

The build-up period for banana farms reflects the gradual, half a hectare per year, planting of bananas. The cropping pattern, therefore, varies during the establishment period and is shown in the following table as (hectares in each year):

	Year 1	2	3	4
Bananas				
Year 1	0.5	0.5	0.5	0.5
Years 2,3 and 4	-	0.5	1.0	1.5
Total	0.5	1.0	1.5	2.0
Maize (gu)	1.9	1.4	0.9	0.4
Sesame (der)	1.9	1.4	0.9	0.4
Vegetables (gu and der)	0.2	0.2	0.2	0.2

The changing pattern assumes that each holding is fully utilised every year at the target cropping intensity of 200% for annual crops.

The build-up of benefits on the basis of the above assumptions is given in Table 7.21.

7.11.5 Economic Analysis

The project's flow of costs and benefits at economic prices is given in Table 7.21 using the two base price assumptions, High and Low, are shown. The resulting cost-benefit ratios and economic internal rates of return (IRR) indicate an economically viable project at both price level assumptions.

The results being:

	Benefit : cost ratio (at 10%)	IRR (%)
High Prices	3.4 : 1	35.3
Low Prices	2.7 : 1	27.9

The results are as expected bearing in mind the high value of the scheme's major crop and the low proportion, 20%, of other crops.

Sensitivity analyses were undertaken and the results are summarised in Table 7.22. These indicate that the viability is equally sensitive to increases in costs as to decreases in benefits. If costs were to rise by 15% and benefits fall by the same amount the cost-benefit ratios would fall to 2.5 (High) and 2.0 (Low) and IRRs from 35.3% to 27.5% with the High Price assumptions and 27.9% to 21.4% with Low Prices.

TABLE 7.21

Banana Pilot Project Economic Costs and Returns
(US$ '000)

Year	High Prices			Low Prices		
	Costs	Incremental benefits	Net benefits	Costs	Incremental benefits	Net benefits
1	2 401.3	-	(2 401.3)	2 401.3	-	(2 401.3)
2	287.1	153.1	(134.0)	287.1	80.6	(206.5)
3	356.1	569.3	213.2	356.1	366.9	10.8
4	320.1	1 194.9	874.8	320.1	820.9	500.8
5	297.0	1 775.0	1 478.0	297.0	1 316.8	1 019.8
6	295.9	2 040.8	1 744.9	295.9	1 611.8	1 315.9
7	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
8	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
9	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
10	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
11	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
12	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
13	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
14	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
15	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
16	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
17	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
18	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
19	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
20	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
21	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
22	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
23	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
24	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
25	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
26	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
27	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
28	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
29	172.7	2 094.5	1 921.8	172.7	1 654.0	1 481.3
30	172.7	2 167.4	1 994.7	172.7	1 726.9	1 554.2

TABLE 7.22

Summary of Economic Sensitivity Analyses

Assumption	Net present value: Costs (US$ '000)	Net present value: Incremental benefits (US$ '000)	Net present value: Net benefits (US$ '000)	Benefit : cost ratio	IRR (%)
Base case:					
High Prices	4 536	15 448	10 912	3.4	35.3
Low Prices	4 536	12 021	7 485	2.7	27.9
Costs + 15% Benefits Unchanged:					
High Prices	5 220	15 448	10 228	3.0	31.5
Low Prices	5 220	12 021	6 801	2.3	24.8
Benefits -15% Costs Unchanged:					
High Prices	4 536	13 213	8 677	2.9	30.9
Low Prices	4 536	10 220	5 684	2.3	24.3
Costs +15% Benefits -15%:					
High Prices	5 220	13 213	7 993	2.5	27.5
Low Prices	5 220	10 220	5 000	2.0	21.4

HOMBOY AREA AND SMALLHOLDER BANANA CULTIVATION

IN THE LOWER JUBA VALLEY

AND ASSESSMENT OF AGRICULTURAL BENEFITS

This report comprises the following volumes:

Main Report

Annex 1 - Homboy Feasibility Study

Annex 2 - Smallholder Banana Development

Annex 3 - Assessment of Agricultural and Flood Control Benefits

Album of Drawings

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CHAPTER 1

INTRODUCTION

1.1 The Bardheere Dam Project

Flows in the Juba river vary considerably from year to year and within each year. The minimum annual recorded flow occurred in 1955, at 3 600 million m^3, with a maximum of 9 900 million m^3 in 1961. Low flows occur from January to mid-April (the jilaal season) and on at least three separate occasions since 1940 the Juba has almost ceased to flow. The low flows are inadequate to meet present demands for irrigation water. In contrast, very high flows causing extensive flood damage can occur in both the gu (April to June) and der (September to December) seasons.

Rainfall in the Juba Valley is generally low and unreliable and irrigation is essential for intensive agriculture. Previous estimates have put the area of irrigable land in the valley as high as 175 000 to 200 000 ha. The United States Bureau of Reclamation (USBR) team in the Ministry of Juba Valley Development (MJVD) is in the process of preparing a detailed estimate but, at the time of writing, had not yet produced its final figures. Our impression is that the potential will, in practice, be less than the above figure due to engineering and soils constraints, but will still be very substantial.

Figure 1.1 and Plate Nr 1 in the Album of Drawings show the main features of the valley below the Bardheere dam site. The land currently under irrigation is around 16 000 ha, varying from large mechanised projects (Juba Sugar, Mogambo and Fanoole State Farm) to small private farms of less than 1 ha. Water is provided mainly by pumping from the river, there being only one scheme at present with gravity diversion (Fanoole).

Downstream of Bardheere the river bank-full capacity is about 700 m^3/s, and this decreases progressively in a down-valley direction. During floods exceeding the bank-full capacity, floodplain flow develops and is confined within the relatively narrow meander belt. Downstream of Fanoole the sides broaden and flatten and, during high floods, surplus flow can leave the floodplain and follow paths of old river channels on both east and west banks. Flood bunds have already been constructed to protect irrigated areas such as the Juba Sugar Project and part of the Fanoole State Farm. In the Juba Valley Development Study Technital considered continuous embankments along each bank of the river channel between Fanoole and the coast, a length of 150 km. In addition, Kamsuuma and Arara bridges would need to be raised. From the viewpoint of flood protection this solution does not provide a viable alternative to Bardheere reservoir.

Further exploitation of the valley's considerable irrigation potential is heavily dependent on the provision of additional water supplies in the jilaal season. Existing jilaal flows are already fully utilised in most years and intensive irrigated cropping, on which the economic and financial feasibility of new development will depend, is therefore not easy to achieve. The Bardheere Dam Project (BDP) would enable this constraint to be overcome, as well as virtually eliminating downstream flooding, and is therefore crucial to the valley's future economic expansion. In addition, the hydro-electricity it would generate would provide major benefits to irrigated agriculture as well as to other sectors of the economy in the Valley and elsewhere in southern Somalia.

Potential irrigation development and water demands below Dolo have been the subject of several reports, but the principal guide to ultimate development potential is the Juba Valley Development Plan (Technital 1975), as up-dated and revised by Impresit in 1979. More recently, Lahmeyer International (1985) carried out a study on possible interim storage measures prior to the construction of Bardheere Dam. Between 1983 and 1986 Agrar und Hydrotechnik (AHT) has prepared a series of reports on specific aspects of the master planning of the Juba Valley. AHT is now about to start a major master planning study for the valley as a whole, covering all aspects of its development.

The Bardheere Dam would create a reservoir some 200 km long, with an average width of 2 km and a maximum width of 13 km. At Maximum Normal Water Level the reservoir would inundate an area of some 32 000 ha, rising to 42 500 ha at Maximum Exceptional Water Level. Total storage capacity would be 4 100 million m^3. Installed hydroelectric (HEP) generating capacity would be 105 MW, which would be sufficient to meet electric power demands in southern Somalia until well into the next century. Recent estimates indicate that the HEP benefits would meet at least two-thirds, and probably more, of the BDP's cost but that a significant contribution from agriculture and flood control would be necessary to assure the economic viability of the project.

With its massive storage capacity, the dam would achieve a large degree of regulation of river flows. In its natural state, the Juba tends to be either in low flow or high flow. The proposed dam would produce a flow regime varying quite closely around the annual mean. Harmful flooding would be limited to all but the rarest occurrences and low flows could be maintained to meet all foreseeable irrigation demands.

1.2 Scope and Objectives of the Study

As specified in Section 3.4 of the Terms of Reference, the basic objective of this part of the Homboy Study is to assess the likely agricultural and flood control benefits from the construction of Bardheere Dam, taking account of its effects on both existing agriculture and future new development. The latter was to be based on the development of 20 000 to 26 000 ha up to the year 2005. Since this would cover only the first 10 years after the dam's completion in 1995, we have considered a longer time horizon, up to the year 2025, and a large area for eventual irrigation.

We understand that the technical and economic data from the assessment will be used in the formal appraisal of the Bardheere Dam Project (BDP) which is due to be carried out in late 1987 or early 1988. Our data and findings have therefore been presented in a form which is very suitable for subsequent use by others. In particular, the foreign exchange contents of benefits and costs have been quantified in terms of US Dollars as well as Somali Shillings, so that benefits and costs can be recalculated if exchange rates change or a different foreign exchange (FE) shadow price needs to be applied.

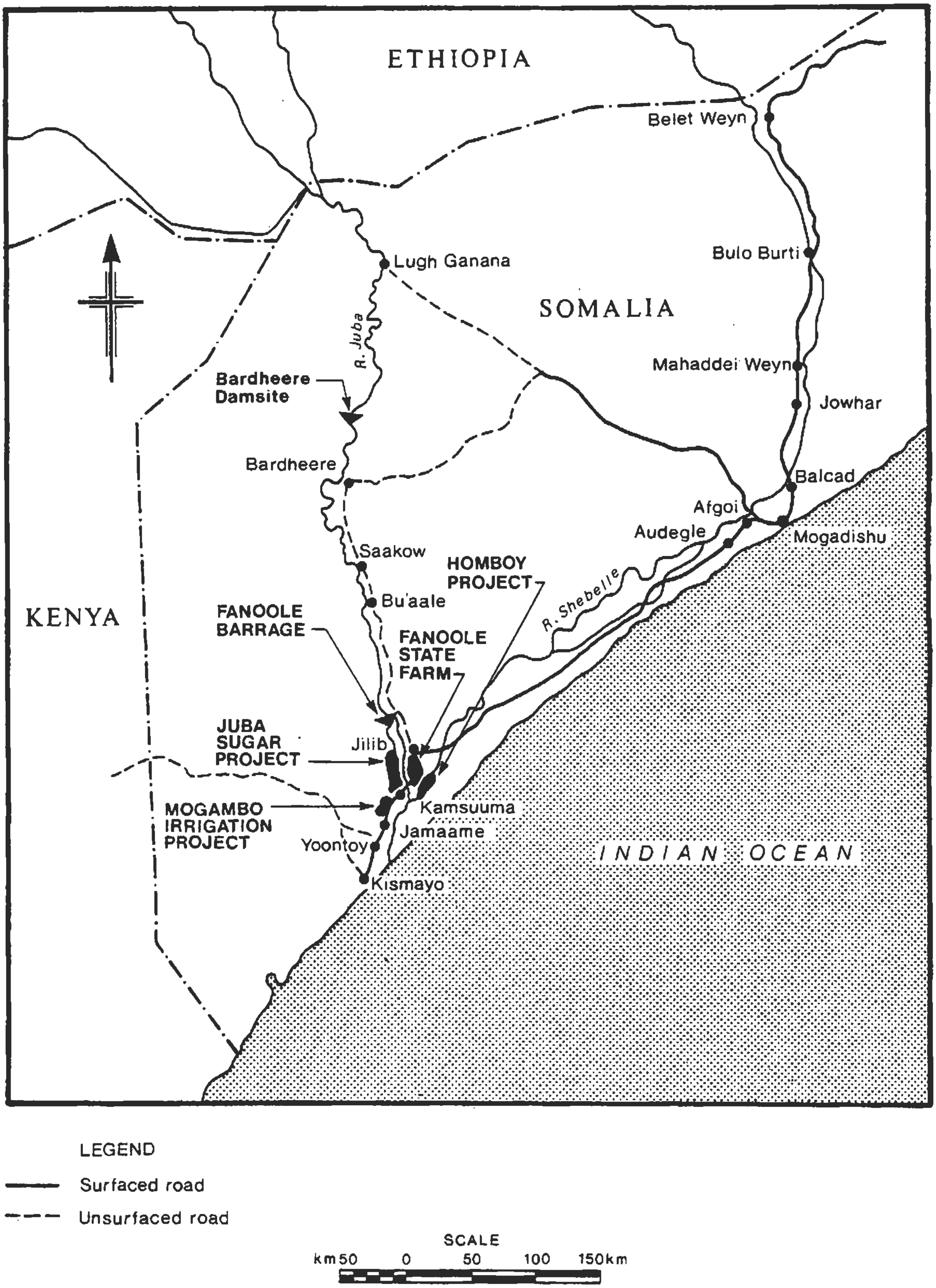
1.3 Sources and Availability of Data

Particular sources of data for the study have included the following:

(i) Discussions with the AHT advisory team in the MJVD and various AHT reports, including:

Deshek and small and medium scale agriculture in the Juba Valley (1984);

Figure 1.1
Location Map



- Development of Juba Valley, Present Situation, Potential Planning (1985);

- Assessment of Flood Damage in the Juba Valley, Gu 1985 (1985);

- Rainfed Agriculture in the Juba Valley (1985).

- Impact of the Bardheere Dam on the Development of the Traditional Agricultural System (Desheks) in the Juba Valley (1986).

(ii) Data from staff of the MJVD, the Juba Environmental and Socio-economic Survey (JESS), which is being undertaken for MJVD, the USBR team and other organisations.

(iii) Data generated by the other two sub-studies within the present Homboy Study, for the Homboy Irrigation Project and Smallholder Banana Development.

(iv) Information supplied by the Juba Sugar Project (JSP) and Booker Agriculture International (BAI) Limited, which provides management and technical assistance to the JSP.

(v) Information provided by staff of the Mogambo Irrigation Project, including the Australian Technical Assistance (TA) team supplied by John Bingle International Pty, personnel of Sir M. MacDonald & Partners (MMP) and Somali staff.

(vi) Information from staff of Somalfruit, the organisation responsible for banana marketing and production in Somalia, the Fanoole State Farm Project and other Government staff in the Lower Juba Valley.

(vii) Our informal field survey to assess the effects of jilaal water shortages on banana farms.

(viii) Existing reports produced by MMP, Hunting Technical Services Ltd. (HTS), Lahmeyer International, Electroconsult, Technital, Impresit and IBRD (the World Bank).

In general, the data base has been found to be reasonably adequate for most of the analyses carried out, though at a pre-feasibility rather than feasibility study level. Perhaps the most serious gap concerns flood damage; only two assessments have been made, for the 1981 flood (MMP - HTS) and the 1985 flood (AHT). Inevitably, therefore, the quantification of the long-term BDP benefits from eliminating flooding are very approximate in nature. The lack of final figures on the area and characteristics of irrigable land which would be developed is not considered to be a serious constraint for the study. It seems probable that more than sufficient land should be available to fully occupy the available project implementation capacity for at least the first 10 to 20 years after completion of the dam.

1.4 Price Uncertainties

Clearly, the agricultural input and output prices adopted will have a major impact on the levels of BDP agricultural and flood control benefits calculated in the study. Given the large uncertainties involved, especially regarding future world market price trends, the estimation of future BDP benefits is, unavoidably, a somewhat arbitrary process. An optimistic approach to pricing will result in a high level of economic benefits and a pessimistic approach will have the opposite effect.

The normal convention applied in the economic analysis of projects like BDP and Homboy is to use the most recent long-term world market price forecasts made by IBRD (the World Bank) in their twice-yearly commodity projections. In this case, however, the validity of following this approach is questionable, because, as shown in Table 1.1, the October 1986 projections for many of the crops are very pessimistic and predict world market prices well below recent (1980 to 1985) levels or those prevailing in 1970, which is presented in the October 1986 forecasts as a reference year.

TABLE 1.1

IBRD World Market Actual and Projected Prices of Selected Commodities (US$/tonne at 1985 Constant Prices)

Commodity	IBRD projected price Year 2000	Actual prices 1970	Actual prices 1980 to 1985
Crops			
Rice	206	395	316
Maize	94	160	122
Sorghum	89	142	116
Soya beans (as representative of oilseeds)	200	321	263
Cotton lint	1 650	1 730	1 700
Sugar	253	222	255
Bananas	321	453	382
Fertilisers			
Urea	171	132	169
Triple superphosphate	147	116	141
DAP	206	148	186
Muriate of potash	88	86	90

Source: IBRD Commodity Forecasts, October 1986.

All the crop commodities listed in Table 1.1 had substantially higher prices in 1980 to 1985 and 1970 than is predicted for the long-term future, except for sugar and cotton lint. By contrast, the projected fertiliser prices are the same as, or higher, than past levels.

Despite the rationale presented in the IBRD October 1986 forecasts, it could be argued that, if prices really fall as far as predicted, world output would decline and prices would then begin to rise again in response to market forces. Moreover, there are clear signs that the politically inspired over-production of recent years (e.g. the EEC's Common Agricultural Policy) is now gradually being brought under control.

It is, of course, notoriously difficult to predict future price trends, as IBRD acknowledges in its October 1986 write-up. Given the major uncertainties involved, we have therefore based our analyses on two pricing alternatives, a Low Price Scenario using the year 2000 projected prices and a High Price Scenario using the average prices recorded in the 1980 to 1985 period. This was a period of slow growth, and sometimes even stagnation, in the world economy, rather than an economic boom, so in most cases the values are unlikely to be atypically high.

All prices used in the analyses are presented in terms of 1987 constant values. The IBRD prices quoted above have been adjusted up to 1987 levels by applying the IBRD Manufacturing Unit Value (MUV) Index, which is commonly used in studies of this type as an indicator of world inflation. Values for this index are as follows:

1985	100
1986	113.0
1987	116.5

Prices in 1987 terms are thus taken to be 16.5% above 1985 constant values.

1.5 Report Layout

Following this introductory chapter, Chapter 2 describes the existing situation in the valley in terms of agriculture and hydrology. The likely future situation with and without the BDP is considered in Chapter 3. Chapter 4 then identifies the main forms of BDP agricultural and flood control benefits and outlines our approach to their valuation. BDP benefits from flood control (Chapter 5), existing irrigation schemes (Chapter 6) and new irrigation development (Chapter 7) are then calculated. Chapter 8 assesses the agricultural costs of Bardheere reservoir flooding. In Chapter 9 the results of all these analyses are brought together to estimate the total agricultural and flood control benefits.

CHAPTER 2

EXISTING SITUATION

2.1 General

The area that will benefit from Bardheere Dam is located between the site of the proposed dam, 42 km north of Bardheere, and Goob Weyn, 15 km north of Kismayo. This area is approximately 380 km long and covers about 2 000 km^2 of floodplain in the administrative districts of Bardheere, Saakow, Bu'aale, Jilib, Jamaame and Kismayo.

Population density in this region is not high and the settled population is concentrated along the river. Economic development has been confined mainly to the area between Jilib and Kismayo, where there is a metalled road and easy access to Kismayo port. The valley's three main irrigation projects, the Juba Sugar Project (JSP), Mogambo Irrigation Project and Fanoole State Farm Project, are all located in this area, and the stretch of floodplain between Kamsuma and Yoontoy, downstream of Jamaame, contains all the commercial banana farms.

Average annual rainfall in the valley is about 400 mm, ranging from some 300 mm in the north to almost 700 mm around Jilib and Jamaame. It is heaviest in the gu season (April to June) but also occurs in the der season (September to December). The xagaa season, which follows the gu, is generally dry but cooler than other seasons, and the jilaal (December to early April) is the hottest and driest time of the year. The relatively low rainfall is sufficient to support the traditional low input-low output cropping system, but not commercial farming. Crop failures are common even with the traditional farming system.

The soils of the floodplain consist of levees and sandbanks adjacent to the river, alluvial fans, heterogeneous alluvial sediments and desheks (depressions liable to temporary or permanent flooding). Much of the land is suitable for irrigation, but excessive micro-relief and soil variability and the difficulty of working the widespread clay soils when they are wet are significant problems. The best irrigable land is generally the levee and jiimo (the land between the levees and the desheks soils near the river.

There are no permanent sources of surface water except the river itself. Groundwater potential is limited by water quality problems (high salinity) and the scope for groundwater irrigation is negligible.

2.2 Existing Agriculture

The valley's agriculture comprises the following:

(a) Traditional rainfed cropping.

(b) Cropping on residual moisture in desheks.

(c) Traditional livestock grazing.

(d) Small-scale irrigation along the river, by pumps.

(e) Commercial irrigated banana farming along the Lower Juba.

(f) Co-operative irrigation schemes.

(g) Large scale public sector irrigation on the Juba Sugar, Mogambo and Fanoole State Farm projects.

Livestock are numerous throughout the valley and are an important source of food and cash, as well as being a useful form of security against crop failure. Except in the Bardheere reservoir area itself, the BDP is unlikely to have a major effect on the livestock sector, other than to increase the supply of crop residues for feed and to convert some grazing land to irrigation.

2.3 Rainfed and Deshek Cropping

Table 2.1 shows the cultivated areas under rainfed and deshek cropping as recorded by AHT in 1985 and 1984 respectively.

TABLE 2.1

Cultivated Areas Under Rainfed Farming and Deshek Cropping (ha)

District	Rainfed farm land (1985)	Area under rainfed crop production (1985)	Deshek cultivation (1984)
Bardheere	58 350	40 844	
Saakow	35 250	23 265	1 101
Bu'aale	2 050	1 353	2 206
Jilib	2 450	525	1 525
Jamaame	19 100	9 292	7 883(1) (Jamaame and Kismayo)
Kismayo	1 200	120	
Total	118 400	75 397	12 715

Source: AHT reports

Note: (1) Much of this land is now cropped on rainfall alone, deshek flooding being prevented by the construction of flood bunds.

Based on these figures, rainfed farming is clearly much more significant economically than cropping of desheks. For this study, however, it is not important, except from the viewpoint of valuing the rainfed crop output lost through inundation of the reservoir area, river flooding, and the conversion of rainfed land to irrigation.

The main rainfed crop in Bardheere, Saakow and Bu'aale district is sorghum, with a little sesame, maize and beans. In Jilib, Jamaame and Kismayo districts maize and sesame are the most widely grown, with some beans, cotton and groundnuts. Most land is prepared by hand, although tractor cultivation is used to a limited extent. Fertilisers, agro-chemicals and improved seeds are rarely used. As would be expected with the low and unreliable rainfall, crop yields are low.

Desheks are defined as natural depressions in the floodplain of the river which are seasonally flooded by river water, and in addition can be flooded by groundwater flow from the river and rainfall runoff. They vary in size, up to a maximum of about 200 ha. Two types of deshek can be distinguished: those which dry out completely in the dry seasons and can be fully used for agricultural production, and deeper-lying desheks where water does not disappear completely and agriculture is only practised at the periphery.

In some desheks the flow of water is channelled from the river through a gap in the bund or a natural watercourse. The openings are made before the start of the irrigation season and they are closed as soon as the desheks have been inundated. However, as the gaps are often scoured to larger dimensions they are often difficult to close by hand and a second flood may destroy the crops. To overcome this, gated culverts were introduced in some areas but these are now in very poor condition and have fallen into disuse.

Protection against flooding is generally provided by embankments on the river and the Marine Plain sides of the desheks, although breaching and overtopping are common. There are no external or internal drainage systems, and as soon as the flood levels in the river have receded below the lowest point in the embankment water cannot drain away freely. Recession then becomes dependent on evaporation, infiltration and seepage to the river, resulting in some of the deeper desheks becoming permanent lakes.

Deshek cropping in Saakow district is based almost entirely on maize, which is grown mainly in the gu season, and sesame, grown mainly in the der season. The pattern is similar in Bu'aale district, except that the sesame area in the gu season is negligible. The same is true in the Jilib district, but vegetables and pulses are also of some importance. In Jamaame and Kismayo districts maize and sesame are the main crops, maize production being concentrated in the gu season and sesame in the der and xagaa seasons. The situation in these districts is different to that further upstream, in that in most years the deshek crops are grown on rainfall, not residual moisture from flooding. Except in low rainfall years, river flooding is normally regarded as something to be avoided, because of the crop damage which it causes.

Most cultivated land in the desheks is double-cropped. Crop failures due to lack of moisture or flooding are common and yields are generally similar to those from rainfed crops.

In their October 1986 study on the impact of the dam on deshek cultivation AHT confined its attention largely to Saakow, Bu'aale and Jilib districts, because these are the only districts where genuine flood recession deshek cropping (as opposed to rainfed cropping in deshek land) is important. Their estimates for present deshek cultivation were similar to those given in Table 2.1, and are as follows:

District	Deshek cultivation (ha)
Saakow	1 050
Bu'aale	2 420
Jilib	1 400
Total	4 870

Source: AHT 1986 Deshek Report, Annex 3, Table 1.

The maximum area of existing deshek cultivation which might be affected by the BDP is thus less than 5 000 ha.

2.4 Small-Scale Irrigation Schemes

Water for small-scale irrigation schemes is abstracted from the river by diesel-driven pumps. The pumps are operated and maintained by the farm owner or by a group of farmers or, in some instances, are rented.

AHT (1984) estimated that there were 250 pumps in Bardheere district (one pump per 6 ha) and 13 pumps in Saakow district (one pump per 6.5 ha), with the total number of pumps of all sizes, including the banana farms, between the proposed dam site and the sea being 380 to 390. An aerial survey carried out for JESS by Resource Management and Research (RMR) between September 28th and 30th 1986 arrived at almost the same figure. RMR estimated that there were 408 working pumps in this reach, with a further 213 pumps upstream of the dam site, of which 95 were in the reservoir flooding zone. In its survey RMR gained the impression that a gradual north to south shift in irrigation is taking place in Bardheere district, and that deshek cultivation is in decline and is less important than river bank irrigation and rainfed cropping.

Pump capacities range from 5 to 30 l/s, with an average of about 20 l/s at a maximum 8 m head. Although the availability of fuel, tools and spare parts is poor the majority of the pumps are in reasonable working order. At the time of the 1984 survey onions were the main crop, being grown for the Mogadishu and other urban markets. Since 1984, however, the range of irrigated crops has been extended, with staple crops like maize and sesame being grown, as well as high value vegetables and fruit.

The pumps discharge into an unlined earth canal network; to prevent excessive conveyance seepage losses the pumps may be moved to be nearer the area they are required to supply. The canals are generally in poor condition and are often aligned incorrectly. There are no control or measurement structures. Field irrigation is carried out by small basins on a 5 to 10 day rotation basis. The basins are fed from field channels which offtake from the canals, the field channels being typically 50 m long at a spacing of 10 to 15 m. Irrigation normally takes place for 5 to 6 hours during the daytime only, but at times of high water requirement some night irrigation is carried out. Overall efficiencies are estimated at 50%.

Flood bunds 1 m to 1.5 m high have been constructed in Bardheere district to protect against runoff from the adjacent Marine Plain and flooding from the river. There are no internal drainage systems.

Development so far has been confined largely to the fertile levee land along the river. In many places the area of such land is limited, which may restrict further expansion. Nevertheless, small-scale pump irrigation is important in various parts of the valley. It would benefit substantially from the BDP, due to the resultant year-round availability of water and the removal of the flood hazard. Some schemes might also be able to convert from diesel to electric pumping.

2.5 The Banana Farms

2.5.1 General

The Lower Juba Valley has been a major producer of irrigated bananas for export for many years. Commercial production was started in the 1920s by Italian farmers eager to exploit the expanding market for bananas in Italy. Somalia was granted preferential access to this market, which, under (EEC) European Common Market provisions, still continues. Exports of bananas from the Lower Juba reached a peak of 73 000 tonnes in 1972, but have since declined to 20 000 to 27 000 tonnes per annum in the 1980 to 1985 period. Low producer prices, shortages of imported inputs and the emigration of many Italian growers in the 1970s all contributed to this decline.

Recently, however, the industry has begun to recover. A key factor has been the formation of a joint venture company, Somalfruit, between Italian commercial fruit marketing interests and the Government's former National Banana Board, the share holdings of each being 60% and 40% respectively. Somalfruit's management has substantial Italian involvement and the organisation is run on normal commercial lines rather than as a parastatal. It has sole responsibility for the Somali banana industry and carries out all the functions involved in the collection, grading, packing, transport, shipping and export marketing of bananas. The company also supplies most of the inputs required, medium-term credit, machinery servicing, the local manufacture of spare parts and supervision and technical assistance to growers. It also has some banana farms itself. A detailed description of the banana industry and Somalfruit is given in Annex 2.

2.5.2 Banana Production and Areas

Table 2.2 summarises banana areas, exports and yields in recent years. The yield figures refer only to export quantity bananas; output of bananas of below export quality is not included.

The current banana area of 2 279 ha is less than half the peak reached in 1973 and yields are also well below those achieved in the early 1970s. Since export market prospects for Somali bananas are quite favourable the indications are that considerable scope exists for increasing present areas and yields in the Lower Juba. Another factor is that water availability on the Shebelle river, where the rest of the country's export bananas are grown, is becoming an increasing problem. This may restrict the potential for raising Shebelle banana output and thus leave more room for expansion on the Juba.

Yields vary widely in terms of both gross output per hectare and the percentages of export and reject quality within this gross output. Reject rates may be as high as 50% for some growers. Two main categories of producers have been

TABLE 2.2

Lower Juba Banana Areas, Exports and Export Yields (1960 to 1986)

Year	Banana area (ha) Lower Juba	Banana area (ha) All Somalia[1]	Exports (tonnes) Lower Juba	Exports (tonnes) All Somalia[1]	Export yield (t/ha)
1960-1965 average	NA	NA	32 920	88 581	NA
1966-1970 average	NA	NA	48 293	92 261	NA
1971	NA	NA	66 605	103 314	NA
1972	4 428	9 128	73 282	133 934	16.5
1973	5 075	9 770	65 208	111 931	12.8
1974	3 964	9 037	65 830	107 299	16.6
1975	4 133	8 342	46 846	81 841	11.3
1976	3 435	7 422	38 658	72 531	11.3
1977	2 488	6 383	25 000	53 812	10.0
1978	2 820	6 831	24 218	57 079	8.6
1979	NA	NA	NA	36 657	NA
1980	NA	NA	NA	35 491	NA
1981	1 804	4 100[2]	15 073	34 255	8.3
1982	1 650	4 800[2]	21 786	50 665	13.2
1983	2 052	4 700[2]	27 478	62 448	13.4
1984	2 571	4 492	21 534	47 855	8.3
1985	2 010[3]	5 121	20 395	45 321	10.1
1986 (September)	2 276	5 839	NA	NA	NA

Notes: (1) The only other producing area is the Shebelle Valley.
(2) Estimates.
(3) There were very bad floods in 1985, which destroyed several hundred hectares of bananas.

Source: Somalfruit and Annex 2.

identified, medium technology and low technology growers. Medium technology growers are estimated to obtain average export yields of 20.0 t/ha over a 4 year crop life, as compared with 10.6 t/ha over 3 years for those applying low technology. Assuming that the process of technical improvement being implemented by Somalfruit continues, long-term future average yields for all growers have been taken to be 19.75 t/ha per annum of export fruit and 5.0 t/ha per annum of reject quality fruit for local sale. This is not far above those achieved in the early 1970s.

There are now 61 banana farms and 54 producers in the Lower Juba, almost all private farmers, the majority having between 11 ha and 50 ha of bananas. Of the total nominal area of 8 287 ha, only 3 315 ha are actually under banana production. Due to the need for a fallow period of at least one year between crops, to control nematodes and other pests and diseases, the actual banana crop area of 2 276 ha occupies only 69% of the land.

Almost 5 000 ha of the nominal area of banana farms is abandoned, unutilised or used for low intensity annual cropping, and could be redeveloped for banana production. Considerable scope thus exists for expanding the Lower Juba banana area in the future.

The banana farms are located along the river betwen Kamsuuma and Yoontoy, being sited mainly on the medium to medium-heavy levee soils near the river. These are reasonably fertile and easy to cultivate, but drainage is a common problem and a surface drainage system is necessary for high yields.

In addition to bananas, there are limited areas of grapefruit, coconuts, mangoes and other tree crops on many farms. Some maize, sesame and other traditional crops are also grown, mainly for the labour force rather than for commercial purposes.

Somalia's main export markets are Italy and the Middle East, especially Saudi Arabia. With the EEC preferential access to the former and Somalia's transport cost advantage to the latter, prospects for raising exports are favourable. In Annex 2 it is estimated that banana exports could reach 225 000 tonnes by 2005, which would require 13 300 ha of bananas. Even if the Shebelle were to reach its historical maximum of 5 700 ha of bananas, which is probably unlikely due to water shortage, there would appear to be sufficient market potential for at least 7 000 to 8 000 ha in the Lower Juba, more than three times the 1986 area of 2 276 ha.

2.5.3 Irrigation and Flood Protection

Irrigation water is abstracted from the river by diesel-driven pumps, with a typical capacity of 150 to 200 l/s. There are 120 such units, an average of one pump per 30 ha. Difficulties are experienced with shortages of fuel and spare parts but, in general, the farmers manage to keep their pumps operational.

The water distribution system is similar to the small-scale farms, although in some instances the main canal is lined with concrete blocks. The canals are generally in reasonable condition, partly due to the use of machines for construction and maintenance purposes. There are a few control and distribution structures but no flow measurement facilities. The bananas are irrigated by furrows spaced at about 2.5 m, each furrow being typically 100 m long. Water application appears to be quite good, and laser-controlled land levelling is carried out on some of the larger farms. The average irrigation interval is two weeks and irrigation typically takes place for 10 hours during the daytime, rising to as much as 24 hours in the jilaal season, if water is available in the river (see below).

The banana farmers generally have bunds to protect against flooding from the river and run-off from the adjoining Marine Plain. Most schemes also have an internal drainage system for removal of excess surface water. This consists of 1.5 to 2.0 m deep open drains at a spacing of 100 m, connected to a main drainage system which discharges either back to the river or to localised depressions. For much of the year gravity disposal is not possible, and unless pumping is carried out the drains can remain full of water.

2.5.4 Flooding and Water Availability Problems

Exploitation of the potential for expansion discussed in (b) above will not be possible without adequate jilaal water supplies and flood control, which can be achieved only through construction of Bardheere Dam. Banana growers regard these two problems as their main constraints. Serious flood damage occurred in 1977, 1981 and 1985, despite most farms being flood-bunded. The possibility of flood damage adversely affects farmers' confidence in the future and their willingness to invest the large sums involved in expanding their banana areas and improving productivity. Bananas are very vulnerable to flood damage; plant death results if the plant stands in water for much more than three days.

Irrigation water availability is of extreme concern to most growers, because shortages occur almost every year in the jilaal season. Occasionally the river even dries up completely, apart from isolated pools. With the low river levels and resultant greater pumping head, more pumping is needed than in the rest of the year, with 24 hour operation often being necessary. Even then, supplies may well be inadequate, especially as crop water requirements are highest in this season.

Jilaal water shortages cause reductions in banana yields and quality and some plant deaths. Many farmers complain that water shortages have increased since the development of the large irrigation projects. Juba Sugar Project and Fanoole are well upstream of Kamsuuma and Mogambo is roughly halfway between Kamsuuma and Jamaame.

Another problem is that, during the first few days of rising water levels after the jilaal, the river water salinity is high. Use of this water for irrigation can cause damage to the bananas, which are already under stress as a result of inadequate irrigation during the jilaal. In the areas downstream of Jamaame damage also sometimes occurs due to the pumping of saline water brought up by tidal incursions of sea water during the jilaal season.

The flowering and bunch size of a banana plant depends on previous growth, fruit development depends on contemporary events, and total yields depend on the continuity and vigour of renewal growth. Thus bananas make high demands on a continuous supply of water. Even a short period of 14 to 21 days drought occurring just after flowering would result in physiological disaster, such as distorted and withered fruits, and a loss of quality and yield, together with delayed growth of the following ratoon crop amounting to a crop loss of 5 to 10%.

With the longer periods of water shortage that often occur in the jilaal the loss would be correspondingly greater. Increasing water shortage causes wilting, loss of vigour and fruit disorders such as premature ripening and malformation. Prolonged water stress causes the stems to break and collapse, with a consequent cessation of renewal growth. A drought of 60 days could reduce yields by over 50%, as new growth stimulated by the recommencement of irrigation would take nine months to crop, thereby losing one or two ratoon crops.

Reliable data on the effects of jilaal water shortages on the banana farms are not available. In an attempt to obtain information on how the jilaal affects farmers in practice, a brief and informal survey was conducted in November 1986 and February 1987, based on farmer interviews. Some difficulties were encountered in finding sufficient farmers to interview, but eventually 13 were questioned, located as follows:

Location	Number of farms
Kamsuuma to Mogambo Project pump station	9
Mogambo to Jamaame	2
Jamaame to Yoontoy	2
Total	13

Although the coverage was thus somewhat unrepresentative of the geographical distribution of banana farms within the Kamsuuma to Yoontoy, it provided much useful information. The main findings regarding water availability were as follows:

(a) Most farmers between Kamsuuma and Mogambo have serious irrigation supply problems from January until early April. Most farmers have some weeks of little or no water and pump for up to 24 hours per day whenever water is available. Many have to dig wells or channels in the river bed in order to maintain supplies and some of these can only be pumped for a few hours before they dry up. They then have to be left for several hours to replenish themselves. The situation in recent years was reported to have been as follows:

1984 - six out of eight farms stopped pumping for up to two months.

1985 - six out of nine farms stopped pumping for 3 to 5 weeks.

1986 - five out of nine farms stopped pumping for 3 to 5 weeks.

1987 - three out of eight farms expected to have to stop pumping by the end of February.

(b) The two farms between Mogambo and Jamaame also reported severe water supply problems but in recent years have not had to stop pumping entirely except in 1984.

(c) Information from the two farmers interviewed downstream of Jamaame suggested that the situation is better than further upstream, perhaps because the tides help to keep water levels up. On the other hand, this could also raise water salinity levels. No pump stoppages due to too low water levels were reported.

The general picture, therefore is that the pumping problems increase as one goes upstream. Jilaal pumping hours per day were considered to be roughly double the 'normal' hours.

As regards the impact on the banana crop, most farmers consider that the jilaal water supply problems reduce both yields and quality (i.e. the percentage of output being accepted for export) substantially, yields being somewhat more affected than quality. Effects on plant health and mortality were felt to be less marked, but four farmers mentioned a significant level of plant deaths resulting from the jilaal.

A senior member of the Somalfruit technical staff was also questioned as to the impact of the jilaal. In his view its effects are as follows, in descending order of importance:

(i) Yields and quality are reduced. In a good jilaal year export output might go down by only 5 to 10%, whereas in a bad year the reduction could be as much as 30%.

(ii) No planting of new bananas is possible in the jilaal, so attainment of a regular flow of exports during the year is made more difficult. The fact that there is a good market in Italy for bananas between February and May, during and soon after the jilaal, makes this effect more serious.

(iii) Plant damage and deaths are significant and more replanting is necessary than if jilaal water supplies were adequate.

The assumptions made regarding the benefits to existing banana farms from providing adequate jilaal river flows and eliminating river flooding through the BDP are discussed in Section 6.4.

2.6 Juba Sugar Project

2.6.1 General

The Juba Sugar Project (JSP) is located on the right bank near Mareerey village, opposite Jilib. The existing Phase I covers 7 365 ha net irrigable area, of which all but 400 ha have overhead (almost all sprinkler) irrigation. It is supplied by two river pump stations, each of 5 m^3/s capacity, but a gravity supply canal offtaking from upstream of Fanoole barrage is now under construction. The land is mainly levee soils and is capable of producing high cane yields. Factory capacity is 70 000 tonnes sugar per annum over a nine month harvesting season.

JSP is run on a commercial basis, under the Ministry of Industry (formerly the Ministry of Commerce and Industry), with management and technical assistance provided by Booker Agriculture International (BAI) of London. Sugar production began in 1980, only five years after the start of the feasibility study, an impressive rate of implementation. Certain parts of the estate's development are, however, not completed, due to financial constraints, and it still lacks a drainage system and an adequate all-weather road network.

Though Government owned, JSP has been allowed to set its own pay and conditions since 1982. To some extent this has eased the difficulty of recruiting and retaining skilled staff. Housing and other facilities are provided and there is a large training programme. The total permanent labour force is about 2 100, with up to 5 000 casual labourers employed at peak times.

In comparison with most other large irrigation schemes in Somalia, JSP has been reasonably successful, despite not meeting its production targets in full (see below). Development of a second phase of 6 300 ha is proposed, after Bardheere water becomes available.

2.6.2 Capital Costs

Capital expenditure to date has totalled about US$ 201 million, as shown in Table 2.3.

TABLE 2.3

JSP I Capital Costs

Item	US$ million
Agriculture and land development	74.2
Sugar factory and equipment	62.0
Administrative infrastructure	36.5
Consultants, pre-operating costs	23.1
Working capital	5.2
Total	201.0

Source: Table 1.1 in 'JSP Medium-Term Development and Associated Foreign Exchange Requirements', BAI 1985.

In its 1985 report on future medium-term JSP development, BAI estimated that a further US$ 5 million would be needed to complete the project. Excluding working capital, total capital costs would thus be US$ 201 million, or approximately US$ 27 800 per irrigable hectare. Since most of this expenditure took place between 1976 and 1983, the cost in terms of 1987 prices would be higher, due to inflation.

The total of US$ 206 million is not far above the original estimate of US$ 175 million. Most of this increase is attributable to the delays and damage caused by the flooding of the project site in November 1977 and cost inflation resulting from delays in foreign exchange availability. Project funding has been provided by the Saudi Fund for Development (US$ 83.3 million as at 1985), the Abu Dhabi Fund for Arab Economic Development (US$ 96.5 million), and the OPEC Special Fund (US$ 10.5 million), the balance of US$ 10.7 million being financed by the Central Bank of Somalia.

2.6.3 JSP I's Performance to Date

JSP I's production target of 70 000 tonnes of mill-white sugar per annum has not yet been achieved. Shortages of foreign exchange, diesel fuel and other essential consumables have been critical constraints and the lack of adequate surface drainage and all-weather roads has also affected output. JSP's management has, however, made commendable efforts to overcome these problems. According to BAI records, the project made a net profit of SoSh 129 million (say, US$ 2.1 million) in 1985, after a loss of SoSh 52 million (US$ 2 million) in 1984. Sugar prices ex-factory are set by Government and the project's profitability is therefore strongly affected by Government pricing policies. A cost analysis made by BAI on the basis of the 1985 budget (Perspective on Costs of Production at JSP) showed total production costs to be US$ 349 per tonne of sugar, broken down as follows:

	US$ per tonne of sugar
Agriculture (including irrigation costs of US$ 22)	195
Factory	78
Administration	58
Finance charges	18
Total	349

This was for a 37 500 tonne per annum level of output. Costs per tonne would be substantially lower if the target output of 70 000 tonnes was achieved. On the other hand, the implied finance charges of only US$ 0.7 million per annum clearly understates the real costs. If the full capital investment of US$ 201 million were included, the annual interest and repayment charges would be very much higher.

Table 2.4 shows cane and sugar outputs and yields for the 1980 to 1986 period and some of the budgetted figures for 1987. By 1986 the cane area had reached about 6 800 ha, only 565 ha short of the full 7 365 ha of irrigable land. Sugar output is expected to be over 40 000 tonnes in 1987. Since 1984 sugar extraction rates (rendements) have been between 9% and 10%, a satisfactory figure considering the various constraints under which the estate operates.

The key factor responsible for the production shortfall has been the cane yields, which since 1983 has been in the 60 to 70 t/ha (harvested) range, despite yields of 80 to 90 t/ha being attained in 1980 and 1982. From the agronomic viewpoint average cane yields of over 100 t/ha are certainly feasible. In its 1985 JSP Medium-Term Development Report, BAI assumed a 105 t/ha yield and a 9.43% rendement, if the main existing constraints other than low jilaal river flows were removed.

The overriding reason for the moderate cane yields has been the inadequate number of crop irrigations applied. In the original feasibility study the theoretical requirements per annum were estimated to be 23.4 irrigations of 82 mm. In its 1985 report, BAI quoted 18 irrigations as the maximum feasible without Bardheere, due to the lack of river flow in February and March. In fact, this number of irrigations has not been approached in recent years, because of diesel fuel shortages. In 1984, for example, only 8.7 irrigations were applied and the number applied in 1985 was expected to be below 12.

Such water shortages cause severe reductions in cane yields. JSP estimates that for each irrigation missed some 300 kg/ha of sugar output or, say, 3 t/ha of cane output, is lost. If only 12 rather than 23 irrigations are supplied, cane yields would therefore go down by 33 t/ha. Taking a potential yield of around 100 t/ha without Bardheere, this reduction would bring the yield down to the 60 to 70 t/ha range, that actually achieved in the years from 1983 to 1986.

TABLE 2.4

JSP Cane Areas and Output and Sugar Output (1980 to 1985)

Year	Area in cane[1] (ha)	Cane area harvested (ha)	Cane harvested		Sugar produced		Rendement (sugar output as % of cane output)
			Total (tonnes)	Tonnes/ha	Total (tonnes)	Tonnes/ha	
1980	NA	1 464	122 924	84.0	7 926	5.41	6.45
1981	NA	3 013	219 381	72.8	14 746	4.89	6.73
1982	NA	3 324	297 744	89.6	22 213	6.68	7.46
1983	5 301	4 909	335 747	68.4	28 113	5.73	8.37
1984	6 374	4 555	289 476	63.6	26 959	5.92	9.31
1985	6 584	6 575	426 060	64.8	39 103	5.95	9.18
1986	6 818	(2)	NA	61.3	(2)	NA	9.87
1987 budget	(3)	(3)	443 460	(3)	42 617	NA	9.61

Notes: (1) Area at the end of the year.

(2) The figures supplied to us by BAI showed 4 538 ha of cane harvested and 27 450 tonnes of sugar produced. These are probably the totals for only part of the year, not for the whole of 1986.

(3) Only parts of the 1987 budget documents were obtained.

Source: 'JSP Medium Term Development and Associated Foreign Exchange Requirements', BAI 1985, and data provided by JSP and BAI staff.

According the JSP staff, irrigation pumping usually stops for 3 to 4 weeks each jilaal season, due to low river flows, although in 1984 it stopped for 6 to 7 weeks. Ideally, the cane needs three irrigations per month in the jilaal, so 2 to 3 irrigations would be missed in a typical jilaal. At 300 kg/ha of sugar output lost per irrigation missed, the loss of output is 0.6 to 0.9 t/ha, or 4 000 to 6 000 tonnes per annum at full cropping.

The project is provided with flood bunds designed for the 1 000 m^3/s (1 in 10 year) flood. Substantial flood damage occurred in 1977 and 1981, but not in 1985, when damage elsewhere in the Lower Juba was considerable.

2.7 Fanoole State Farm Project

Fanoole State Farm is located on the left bank of the Juba just south of Jilib. It is supplied by gravity from the Fanoole barrage by a 50 km long main canal, which will also supply Homboy. Total capacity is 33.6 m^3/s, of which about 21 m^3/s is earmarked for Fanoole and the balance for Homboy. The project's net irrigable area is intended to be 7 750 ha, but the present irrigable area is only 1 600 ha. Construction began in 1974 and progress has been very slow. Total expenditure up to 1985 has been estimated to have been US$ 94 million. Shortage of foreign exchange has been a major reason for the under-performance of the scheme.

Apart from the canal system, the project's engineering works comprise a surface drainage system with pumped outfall, a flood bund (30 km completed out of the 43 km required) and a hydro-electric power (HEP) generating station at Fanoole barrage. Drainage is considered to be essential, especially as the watertable was only 2 to 3 m deep before the project began. Flooding was a serious problem before the construction of the flood bunds, which started in 1981.

HEP generating capacity is 4 600 kW from two turbines, but present output is only 500 kW, which satisfies demand in the project area, Jilib and the other areas served by the fairly long distribution system. The electricity sale price is SoSh 2 per kWh. Minimum head for generation is 3 m, which means that the turbines cannot operate at high river flows. Allowing also for insufficient flows in the jilaal season, the station is expected to operate for an average of eight months per annum.

Fanoole is run as a state farm, under the Ministry of Agriculture (MOA), with assistance provided by the Chinese Government. Cropping is based entirely on rice, and the variety IR 24 is grown. The maximum rice area grown before 1985 was 100 ha per season, but since gu 1985 it has been 600 to 650 ha. Yields are reported to have averaged 4.2 t/ha of unmilled rice per crop; much of the cultivated land is reported to be double-cropped. Diversions from the river are well above the quantities needed to irrigate this area, because of the need to keep the supply canal full, to avoid cracking of the canal lining.

The project has problems with the supply of fuel, crop inputs and other essential items. According to project staff, the other main problems are soil alkalinity and salinity, bird damage and labour shortages.

2.8 Mogambo Irrigation Project

Phase I of the Mogambo Irrigation Project (MIP), comprising 2 050 ha of surface irrigation and 160 ha of sprinkler irrigation, was completed in 1986. Cropping began in 1985. The project works comprise a diesel-powered pump station of 3.7 m^3/s design capacity, a canal system, a pumped drainage system and flood protection bunds. MIP is located on the right bank downstream of JSP and has heavy cracking vertisolic clay soils and some levee soils.

Construction and procurement for Phase I of MIP is due to be completed in early 1988. Expenditure on the main irrigation and drainage contract, M2, is expected to be about US$ 9 600 per hectare. Buildings and services will cost another US$ 2 300 per hectare. Excluding the rice mill (cost US$ 2.60 million) but allowing for purchase of vehicles, equipment and other expenses (excluding agricultural tractors and implements), the total cost is likely to be some US$ 14 000 per hectare.

MIP is managed by the MOA, with technical assistance from an Australian agricultural firm, John Bingle International, and MMP. Originally it was to be run as a state farm, but this policy was subsequently modified to include smallholder settlers with 2 ha holdings. At present, part of the area is operated as a state farm and part as a smallholder scheme, though with very high inputs of machinery operations, fertilisers, etc., from the project authority.

Settlement was first based on settlers from Mogadishu and elsewhere in Somalia, but this has not proved very successful. In 1986 local farmers were brought into the scheme. Many have proved to be enthusiastic farmers and hard workers.

The original plan was to base production on double cropping of paddy rice. To date, however, a more mixed cropping system has been followed. Buildup of watertable levels and soil salinity with rice double cropping is quoted by some MIP staff as a possible danger, although as yet there is little firm evidence that this will take place. Table 2.5 shows the crop areas and yields achieved so far.

Both yields and intensities have been well below target, but MIP is still in the development stage and its cropping has been severely; handicapped by the lack of tractors and implements. Due to procurement delays, these did not begin to arrive in significant numbers until early 1987. In the meantime the project has had to rely on hiring machinery from local banana farmers, which has caused problems. Average rice yields are expected eventually to reach 4 to 5 t/ha.

As yet, the project has not suffered from flooding or difficulties resulting from low jilaal flows. As crop areas increase, however, the latter is expected to become a significant constraint. In early February 1987 the water level in the pump station intake channel was only about 10 cm above the minimum level which can be pumped without risking pumpset damage.

Expansion of MIP to a second phase is planned. Phase IIA would comprise 1 170 ha of surface irrigation, (this excludes a substantial area which had originally been designated for Phase IIA but which had subsequently been developed for commercial banana farming), and Phase IIB would comprise 1 900 ha of sprinkler irrigation. These areas would be supplied from the existing pump station, but with the installation of additional pumpsets. Phase IIA could be developed pre-Bardheere, but Phase IIB should preferably only be developed post-Bardheere. This is so that the sprinkler pumps can make use of the available electrical power rather than rely on diesel fuel, the availability of which can be sporadic.

2.9 Co-operative Irrigation Schemes

Twenty-seven co-operative irrigation schemes totalling 3 600 ha were developed in the late 1970s and were equipped with diesel pumpsets of about 280 l/s capacity. None of these are now operational and the schemes have been abandoned, except for a few cases where individual entrepreneurs or small groups of farmers are irrigating parts of the original scheme area.

TABLE 2.5

Crop Areas and Yields on Mogambo Irrigation Project

Season	Crop	Area (ha)		Average yield (t/ha)	Comments
1985 Gu:	Rice	123		2.8	Weeds and shortage of N and P_2O_5 affected yields
	Maize	40		1.6	
	Total	163		(0.5 - 2.4)	
Der:	Rice	123		4.5	Shortage of N
	Sesame	200		0.3 (0.2 - 0.6)	
	Cowpeas	6		0.9	
	Mung beans	6		0.8	
	Total	335			
1986 Gu:	Rice	500	planted		Severe bird attack and some weed problems
		360	harvested	2.8	
	Maize	50	(sprinkler irrigated)	1.8	Fertilizer, diesel and water shortage
	Total	410	harvested		
Der:	Rice	300			
	Maize	16			
	Sesame	504			
	Safflower	72			
	Cowpeas	28			
	Mung beans	24			
	Sorghum	20			
	Sunflower and soya beans	5			
	Total	969			

Future cropping proposed by MIP staff:

	gu	der	gu	der	gu	der	gu
State farm (1 500 ha)	Rice	Legume	Sunflower	Rice	Legume	Oilseed	Rice
Settlers (600 ha with 300 families)	Maize	Legume Sesame	Sunflower Soya bean	Rice	Legume	Sesame	

Source: Mogambo Irrigation Project

It might be possible to restart some schemes, but this would probably have to be a private sector development. Given the poor performance of co-operatives in Somalia and elsewhere in Africa, there would be little point in trying to reconstitute the failed co-operative societies and the schemes, and they are too small and scattered to justify direct management by Government.

2.10 Juba River Water Allocation and Management

Inadequate river flows in the Juba river in the jilaal period have been a problem for many years. With the development of the three large schemes the situation has become worse, especially as the Fanoole project has the ability to divert large quantities at the barrage. In economic terms the existing banana plantations give the highest returns to water. In the pre-Bardheere period any new developments which reduce the banana plantations' supplies of water in the jilaal season should therefore be avoided.

2.11 Juba River Hydrology

2.11.1 General

The Juba river is formed near Dolo on the Somali-Ethiopian border by the confluence of three tributaries which rise in the Ethiopian highlands. From Dolo to the Indian Ocean the climate of the Juba valley changes gradually from arid to semi-arid. Thus, although local rainfall falling on tributary catchments between Lugh and Bardheere can contribute significantly to flood peaks, the major part of the annual runoff in the Juba results from rainfall on the wetter, upper catchment in Ethiopia. The temporal distribution of this rainfall gives rise to the bimodal flow pattern characteristic of the Juba. Short and pronounced gu floods occur in April and May and more voluminous der floods in October and November. Minor floods occur in the xagaa season between June and September, sustaining the river flow above the annual average. Although the mean annual daily flood peak during the gu is lower than that during the der, exceptional floods are more likely to occur during the gu season (Table 2.6). The der floods are the more reliable.

TABLE 2.6

Bardheere - Empirical Frequencies of Gu and Der Floods

Frequency	Return period (years)	Gu Q (day) maximum (m^3/s)	Der Q (day) maximum (m^3/s)
0.50	2	480	567
MAF	2.3	541	608
0.20	5	807	788
0.10	10	1 024	935
0.05	20	1 231	1 075
Sample size		13	14

MAF = Mean annual flood.
Note: The analysis is based on Bardheere data alone.

Below Bardheere the lack of major tributaries and non-returnable overbank spillage onto the surrounding floodplains have resulted in a progressive decrease in the carrying capacity of the mainstream channel (Table 2.7). Analysis of recorded water levels indicates that the carrying capacities approximate to the mean annual flood.

TABLE 2.7

Juba River - Mainstream Channel Capacities

Reach	(m^3/s)
Lugh-Bardheere	900
Bardheere-Kaitoi	700
Kaitoi-Mareerey	650
Mareerey-Kamsuuma	550
Kamsuuma-Jamaame	460

The same phenomena, together with attenuation in the channel and returnable floodplain storage, cause a similar decrease in flood peaks downstream (Table 2.8).

TABLE 2.8

Juba River - Mean Daily Flows for Empirical Frequencies

Frequency	T	Lugh	Bardheere	Kaitoi	Mareerey	Kamsuuma	Jamaame
0.50	2	835	730	562	565	502	438
MAF	2.3	899	790	594	595	507	451
0.20	5	1 180	1 090	732	727	533	507
0.10	10	1 408	1 335	844	834	554	552
0.05	20	1 627	1 560	952	937	574	595
Sample size		28	n.a.	11	8	5	12

Notes: MAF = Mean annual flood
T = Return period (years)

For all the stations except Bardheere, the values in the above table were obtained by fitting Type 1 extreme value distributions (Gumbel) to available recorded data. For Bardheere a different approach, which is believed to give more realistic estimates of the return periods of major floods, was used and is described below. The poor quality (small sample size, non-concurrent series, poorly defined rating curves) of the data should always be borne in mind when interpreting the above table.

2.11.2 Bardheere Flood Return Periods

The proposed dam will change the hydrology of the Middle and Lower Juba valley by modifying the flows at Bardheere. It is therefore important to define the existing flow pattern at Bardheere to enable comparisons to be made with the expected situation after commissioning of the dam.

Comparison of the available 13 years of recorded annual maximum mean daily flow data at Bardheere with the 28 years of data available at Lugh indicates that the sample at Bardheere includes a disproportionate number of large floods. An extreme value analysis of this sample will therefore tend to underestimate the return periods of large floods.

In an attempt to improve the estimation of return periods of large floods recourse was made to the larger database available for Lugh. The experimental frequencies of floods at Lugh were estimated by fitting an extreme value type I (Gumbel) distribution. These frequencies were then assigned to the peak flows at Bardheere which obviously corresponded to the same flood event at Lugh (dates were compared and the possibility of local runoff between stations studied). Ten flood peaks at Bardheere were plotted against the Lugh probabilities on Gumbel paper and a straight line fitted through the points. The resulting line is not as steep as the line fitted directly to the Bardheere data and therefore gives higher return periods to major floods (Figure 2.1 and Tables 2.9 and 2.10).

TABLE 2.9

Bardheere - Mean Daily Flows for Empirical Frequencies

Frequency	Return period	Mean daily flow (m^3/s) Analysis A	Analysis B
0.50	2	782	730
MAF	2.3	856	790
0.20	5	1 180	1 090
0.10	10	1 443	1 335
0.05	20	1 696	1 560

TABLE 2.10

Bardheere - Estimated Return Periods of 1981 and 1985 Floods

Flood	Peak mean daily flow (m^3/s)	Return period Analysis A	Analysis B
1981	1 568	14	20
1985	1 050	3.7	4.7

Analysis A: Based on 13 recorded annual maxima at Bardheere.

Analysis B: Using experimental probabilities from Lugh with corresponding discharges at Bardheere.

Analysis B is considered to provide the most realistic estimates of flood frequencies at Bardheere and has been used throughout this report.

2.11.3 Flooding

Tables 2.6 and 2.7 show that the estimated mainstream channel capacities correspond approximately to the mean annual flood (T = 2.33 years). Floods of the order of the mean annual flood and smaller are therefore unlikely to cause much flood damage. Indeed, it is these floods which provide the regular water supply for deshek cultivation. With very few exceptions, almost all desheks which rely primarily on the Juba for their water are at elevations which allow them to be flooded, on average, once every one or two years (AHT, 1984). The riparian population is familiar with floods of this magnitude and damage is only caused if, after filling and planting, bund breaches have not been repaired before the arrival of a second flood.

As flood peaks increase above the mean annual flood the mainstream channel capacity is exceeded at more locations and 'exceptional' rather than 'routine' flooding takes place. Increasing flood levels allow a small number of higher level desheks to be cultivated, although the rate of addition of new areas is quickly overtaken by the areas of lower lying desheks which suffer damage because of inadequate flood protection.

Estimates of damage caused by flooding can be made for the 1981 and 1985 gu floods. The 1985 was somewhat bigger than the main annual flood whereas the 1981 flood was much larger. The flood protection benefits accruing from the construction of the Bardheere Dam are based on the probability of occurrence and the cost of damage caused by these two floods.

2.11.4 The 1981 Flood

The 1981 flood resulted primarily from very high flows from Ethiopia but was exacerbated in the Lower Juba valley by high rainfall.

The gu flood waters from Ethiopia arrived earlier than usual in 1981; an initial flood wave passed Lugh on the 17th-18th March, followed one week later by sustained high flows (Figure 2.2). The flood peak of 1 425 m^3/s occurred at Lugh on 1st May with flows exceeding the bank-full capacity over the period 19th April to 6th May.

During 1981 there was, unfortunately, no meteorological station at Lugh. It is known, however, that during March and April there were some heavy local storms which caused toggas to flood briefly (MMP-HTS 1981). Table 2.11 and Figure 2.3 show that in the Lower and Middle Juba valley the gu rains were much heavier than usual. These rains, which increased towards the coast, caused the already very high Juba to overtop its banks at the beginning of April. The heavy rains continued until the end of the first week in May, when the peak of the river flood from Ethiopia reached the Lower Juba. This critical combination of events caused widespread flooding in the lower valley over an extended period of time.

TABLE 2.11

1981 Gu Flood - Comparison of the 10 day Rainfall Totals with Means

	March 1-10	March 11-20	March 21-31	April 1-10	April 11-20	April 21-30	May 1-10	May 11-20	May 21-31	June 1-10	June 11-20	June 21-30
Bardheere:												
1981	10	69	48	30	70	16	393*	19	0	0	0	0
Mean	0	0	0	19	14	37	17	10	0	0	0	1
Mareerey:												
1981	0	2	65	39	163	100	110	22	15	7	5	0
Mean	0	0	0	22	37	44	60	57	31	10	13	15

Sources: Bardheere observed MMP-HTS Flood Report, 1981.
Means and Mareerey from AHT/GTZ, September 1984.

Note: * Considered suspect (MMP-HTS 1981).

Figure 2.1

Flood Flows at Bardheere

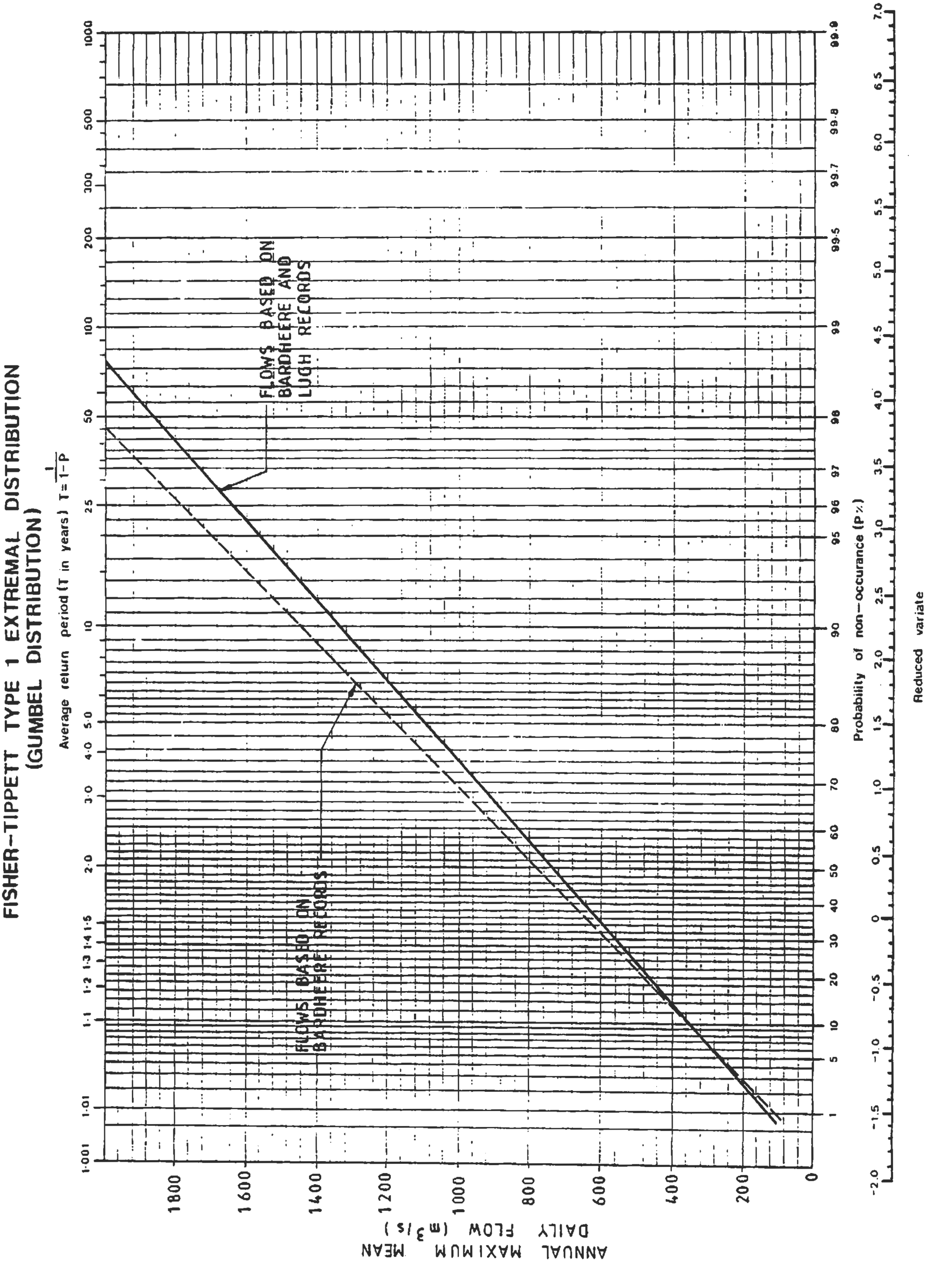


Figure 2.2

Gu Season Flooding 1981 & 1985

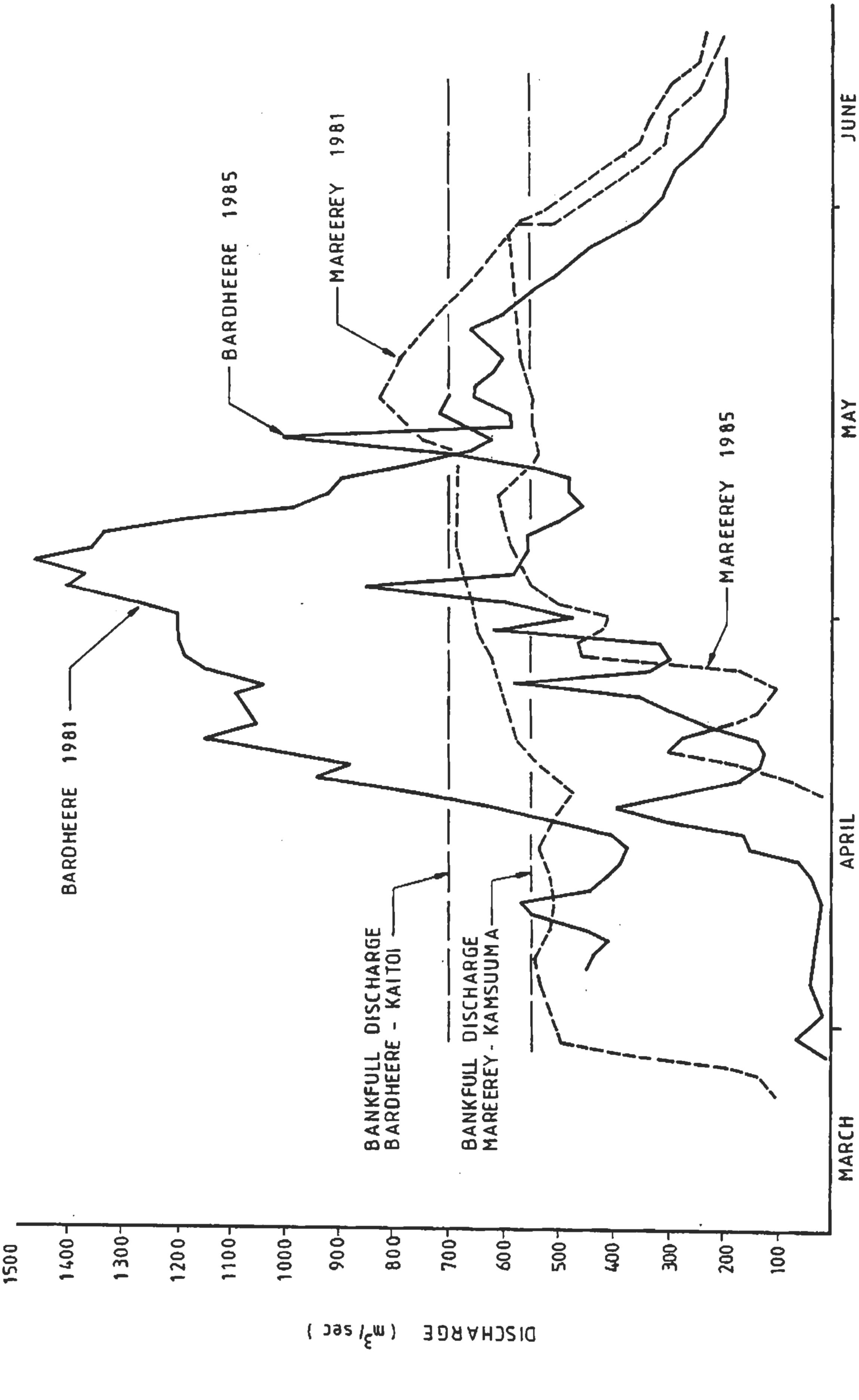
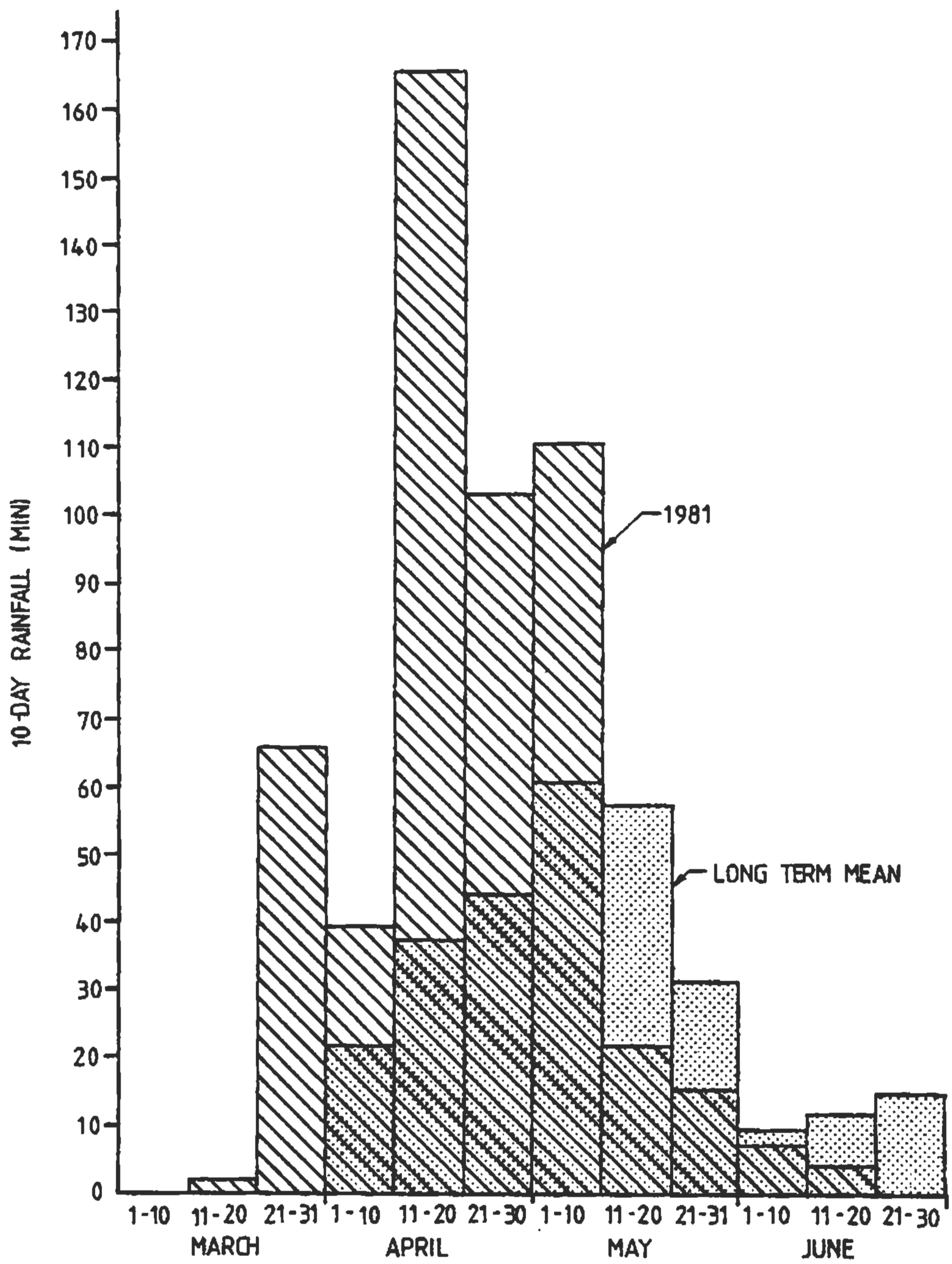


Figure 2:3

1981 Gu Season Rainfall at Mareerey



In this instance, the number of consecutive days of flood exceeding the bank-full capacity gives a better impression of the severity of the flood than the return period of the maximum one day flow in the lower valley (Table 2.12).

TABLE 2.12

Characteristics of the 1981 Gu Flood in Juba Valley

Station	Maximum daily mean flow	Estimated return period	Estimated bank full capacity (m^3/s)	Dates bank full flow capacity	Number of days exceeded
Lugh	1 425	11	900	18/04-08/05	21
Bardheere	1 568	20	700	17/04-19/05	32
Kaitoi	976	23	650		
Mareerey	823	9.3	550	20/04-28/05	39
Jamaame	494	4.2	460	04/04-30/05	57

From the viewpoint of analysing the benefits from flood damage prevention due to the dam, the flood return periods should be those for the main flood-affected region, namely the valley downstream of Fanoole Barrage. Flood return periods are lower in this reach than at Bardheere, because of the reduced river channel capacity and, consequently, more frequent overtopping of the river banks. Taking the average of the Mareerey and Jamaame return periods in Table 2.12 as a reasonable representation of the flood risk for the main flood-prone areas 1981 could be taken as approximating to the 1 in 7 year flood.

2.11.5 The 1985 Flood

As was the case in 1981, the 1985 gu flood was caused by a combination of high river flows crossing the border from Ethiopia and rainfall in the catchment in Somalia. Whereas in 1981 the main causal factor was the high river flows exacerbated by rainfall over the Lower Juba valley, in 1985 extremely heavy rainfall between Lugh and Bardheere was the most important factor.

The maximum flow attained at Lugh was 688 m^3/s, considerably less than the mean annual flood (899 m^3/s). Runoff from catchments downstream of Lugh swelled flow in the river to a peak of 1 065 m^3/s at Bardheere. This high river flow was further supported and flooding made more serious by heavy rainfall in the Lower Juba Valley (Figure 2.4).

Inundation by breaches in and overtopping of river embankments started by the end of April, most seriously affecting areas in Jilib and Jamaame districts. In general, flooding in these districts was restricted to the areas between the river and the main road systems and the river and flood protection bunds. Within those areas the flooding pattern depended on the stability, the intensity and the extent of individual flood bunds.

Heavy rainfall shortly before and during the river flooding, together with insufficient drainage facilities, resulted in large areas being affected by rainfall and rainfall runoff. Rapid drainage of rainwater towards the Juba was impeded by the high water level in the river and by flood bunds which were located across natural drainage lines.

The hydrographs of both the 1981 and 1985 floods are plotted in Figure 2.4. The 1985 flood was much smaller than the 1981 flood as regards both peak flows and flood volumes. This was also reflected in the areas inundated. Unfortunately, less hydrometric data is available for the 1985 flood, the main characteristics of which are summarised in Table 2.13.

TABLE 2.13

Characteristics of the 1985 Gu Flood in the Juba Valley

Station	Maximum daily mean flow (m^3/s)	Estimated return period	Estimated bank full capacity	Dates bank full capacity exceeded	Number of days exceeded
Lugh	688	1.5	900	-	0
Bardheere	1 065	4.7	700	12/05-13/05	2
Mareerey	609	2.5	550	04/05-24/05	20

It is difficult to determine an appropriate return period for the 1985 flood for the Lower Juba valley, due to the absence of data for Jamaame. In terms of river flow alone, the flood at Mareerey was not far above the mean annual flood, but if the unusually heavy rainfall is also taken into account the return period would clearly be greater.

The extent and severity of flooding in 1985 was considerably less than in 1981 which, as described above, has been taken as the 1 in 7 year flood. A reasonable estimate for 1985 might be the 1 in 3 or 4 year flood event.

2.11.6 Juba River Low Flows

The der floods normally end in November and the Juba river flows gradually recede throughout the jilaal season until the following April or May, when the gu flood waters from Ethiopia arrive.

Unfortunately, little reliable river flow data is available for points in the Lower Juba valley. To quantify the availability of water for the Mogambo Irrigation Project the records from Lower Juba stations were extended by correlation with the monthly data from Lugh (MMP, 1979). Since 1978 the Juba Sugar Project has been conscientiously recording water levels upstream of its intake at Mareerey. Furthermore, 15 discharge measurements, all in the low flow range, have been made. With a small amount of infilling, daily discharges are available for all the jilaal seasons from 1977/78 to 1985/86, except for 1984/85. Comparison with concurrent records at Lugh suggests that this sample of data at Mareerey is representative of jilaal flows. It has therefore been used to quantify low flows in the lower Juba.

Ten-day mean discharges for various empirical frequencies derived from the unpatched data record up to 1984 were published by AHT in September 1984 and are reproduced in Table 2.14. Table 2.15 presents the 10-day mean discharges during the jilaal seasons for the infilled and extended data set.

Of prime importance to farmers is the length of periods when they cannot irrigate because levels in the river are too low. Daily data were used to determine the number of consecutive days for which river flow remained less than

Figure 2.4
1985 Gu Season Rainfalls at Mareerey

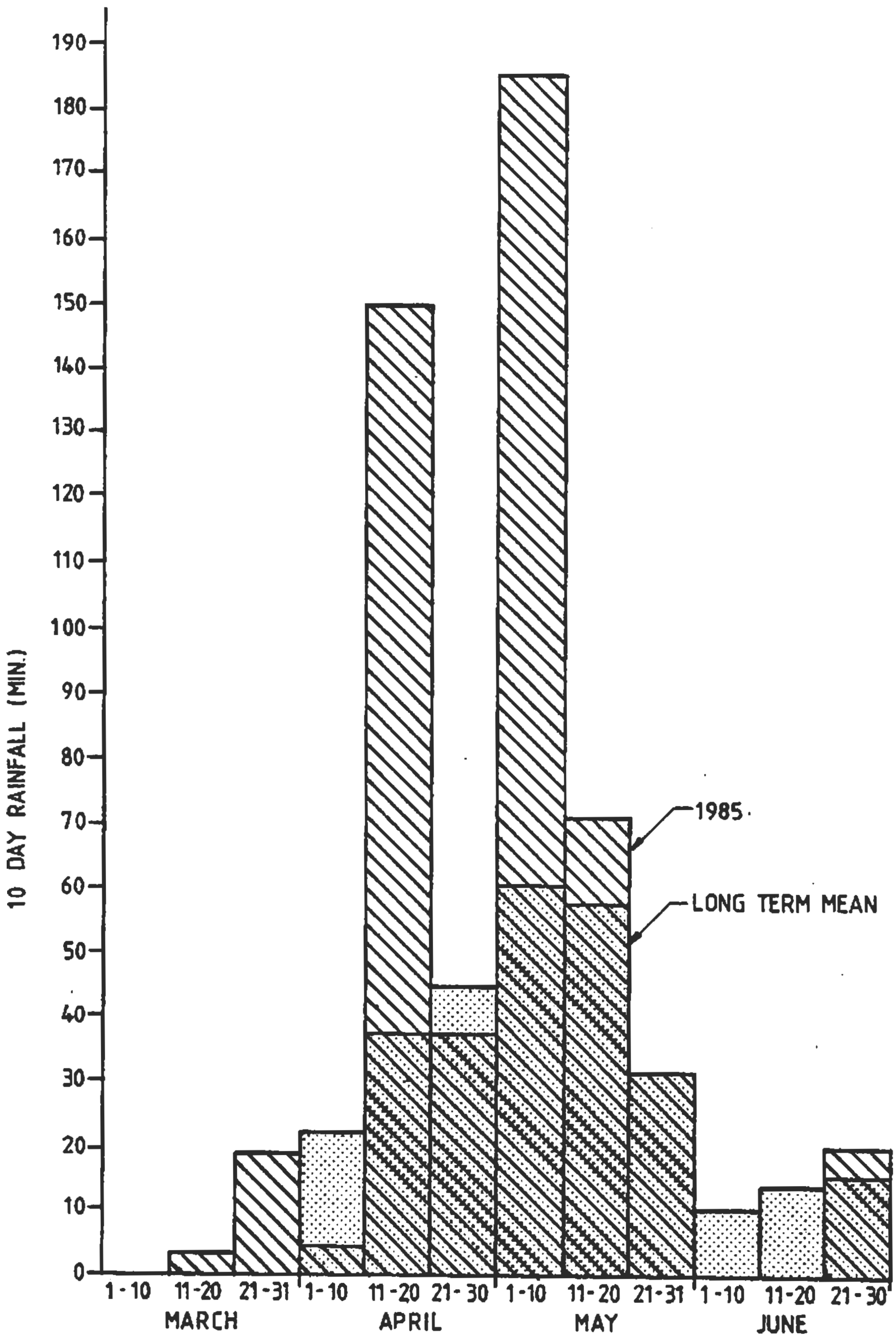
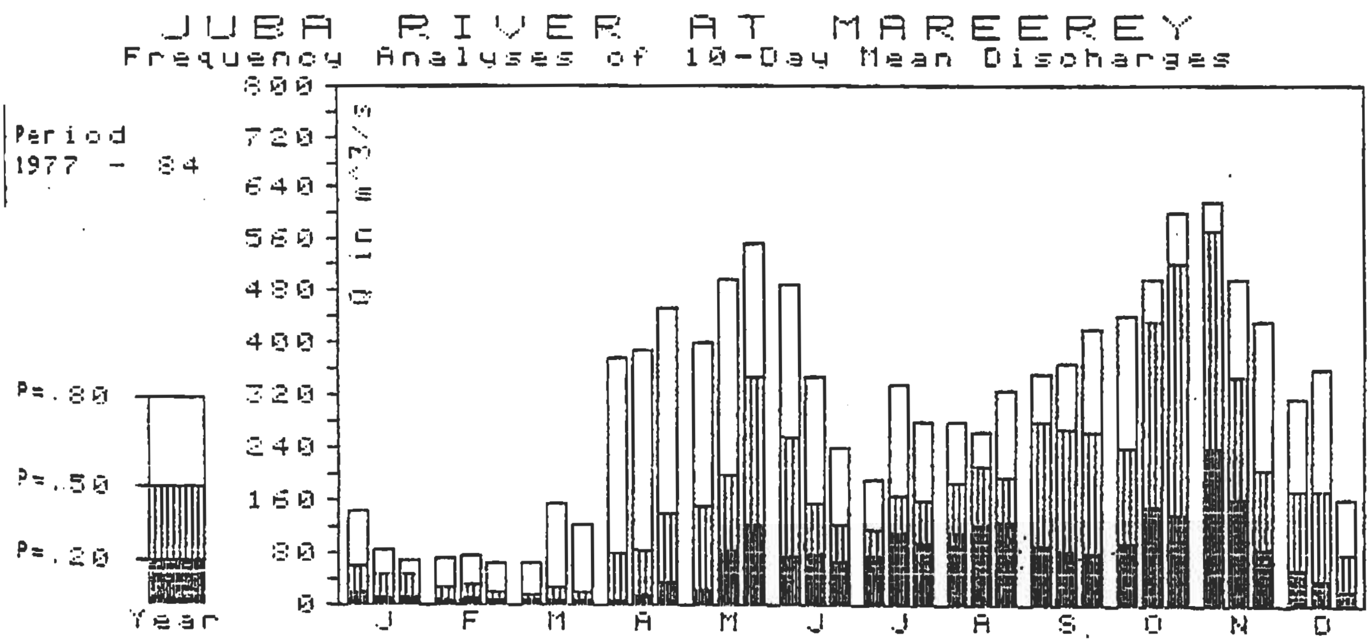


TABLE 2.14

10-Day Mean Discharges in m^3/s Calculated for Empirical Frequencies
Juba River at MAREEREY Period 1977 - 1984

Freq.	Interval	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
.20	1-10	18	6	7	8	22	77	76	113	92	94	238	54
.20	11-20	13	13	6	14	85	80	110	122	85	151	163	41
.20	21-end	12	9	6	36	123	66	97	129	77	140	86	25
.50	1-10	59	27	16	79	151	258	116	188	279	238	572	177
.50	11-20	46	33	26	84	198	155	170	214	268	435	348	176
.50	21-end	47	21	18	138	349	123	160	197	263	520	209	81
.80	1-10	142	71	62	377	400	488	191	280	353	440	616	317
.80	11-20	84	74	154	390	496	347	336	264	367	498	497	362
.80	21-end	67	62	125	453	555	242	279	328	421	603	434	162
N	1-10	6	6	5	6	7	7	6	8	6	7	7	6
N	11-20	6	6	6	6	7	6	8	8	6	6	6	7
N	21-end	7	5	6	6	7	6	8	7	7	7	6	6

N = sample size (years with data complete for resp. interval)



Date of computation : 10.9.1984

NOTE: Reproduced from 'Hydrology of the Juba River' (AHT, 1984)

TABLE 2.15

Mareerey: 10-Day Mean Discharges During Jilaal Season

	December			January			February			March			April		
	1-10	11-20	21-31	1-10	11-20	21-31	1-10	11-20	21-28	1-10	11-20	21-31	1-19	11-20	21-30
1977/78	-	506	263	151	94	69	40	39	33	40	228	178	154	195	142
1978/79	305	217	124	98	70	55	66	84	60	66	44	45	137	132	135
1979/80	68	47	33	27	20	17	12	9	8	6	4	3	0	2	4
1980/81	45	31	19	12	8	5	3	2	2	0	0	164	526	519	617
1981/82	95	70	49	36	28	23	19	17	13	10	9	10	11	36	208
1982/83	259	266	188	171	93	66	75	59	62	43	38	22	22	22	58
1983/84	325	176	114	82	63	47	36	27	21	16	14	13	6	8	22
1985/86	108	65	49	33	24	16	11	9	7	6	5	5	10	85	222
Mean	172	172	105	76	50	37	33	31	26	23	43	55	108	125	176

TABLE 2.16

Mareerey Jilaal Flows: Longest Periods (days) for which Flow ≤ Q

	Q (m^3/s)					
Season	5	10	20	30	40	50
1977/78	0	0	0	0	21	28
1978/79	0	0	0	0	5	10
1979/80	53	78	113	131	147	152
1980/81	59	76	91	98	109	112
1981/82	0	25	75	93	102	112
1982/83	0	0	3	35	37	41
1983/84	2	19	55	78	86	115
1985/86	28	60	80	100	104	110

or equal to 5, 10, 20, 30, 40 and 50 m^3/s during the eight jilaal seasons. The results are presented in Table 2.16. These figures were then fitted to distributions to estimate the length of such 'penury' periods for dry years of various return periods. The results are presented in Table 2.17.

The river flows during the 1985/86 jilaal season were lower than average (Figure 2.5). From the best-fit equations used to produce Table 2.17 the return periods of the 'penury periods' were estimated (Table 2.18). The results suggest that 1985/86 jilaal was a dry year with a return period of between 4 to 5 years. It should be noted, however, that the banana farmers interviewed did not consider 1985/86 to be a particularly bad jilaal; 1984 was felt to be much worse.

TABLE 2.17

Days of Penury for Various Return Periods

Flow (m^3/s)	5	10	20	30	40	50
River level (m)	15.06	15.29	15.61	15.86	16.07	16.26
Mean	18	32	52	67	76	85
1 in 5 year	36	57	85	102	112	122
1 in 10 year	51	77	111	131	141	152

TABLE 2.18

Severity of 1985/86 Jilaal Flows

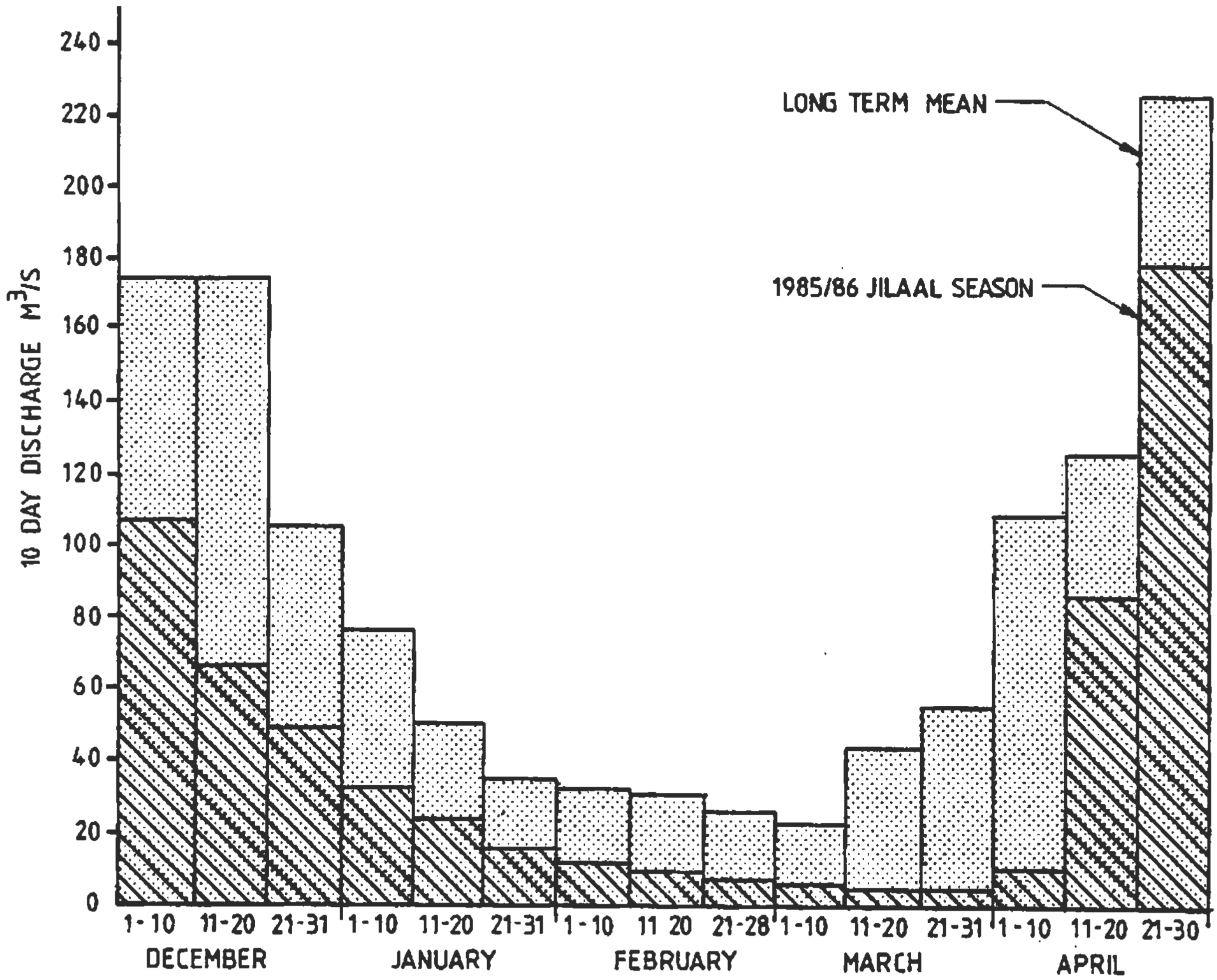
Flow (m^3/s) $\leqslant$	5	10	20	30	40	50
Days, 1985/86	28	60	80	100	104	110
Return period (years)	3.4	5.5	4.4	4.7	4.1	3.8

Figure 2.5 indicates that mean discharges are at their lowest between January 21st and March 10th but that recovery to more 'normal' levels of discharge really starts only in early April. Although the average flows presented in Figure 2.5 do not go below 20 m^3/s these are at Mareerey, well upstream of the main irrigation offtakes/pump stations, except Fanoole Barrage. Mareerey itself can pump up to 10 m^3/s and Mogambo would also abstract substantial quantities. for the main irrigation areas in the Lower Juba the situation is therefore worse than Figure 2.4 indicates. Moreover, the mean is for a 10 year period and the majority of the years are thus from before completion of Fanoole Barrage. The post-Fanoole means are probably less.

Table 2.17 indicates a somewhat less favourable situation as regards low flows. In the average year there is a period of about one month with flows below 10 m^3/s and 2½ weeks with less than 5 m^3/s. As a rough estimate one could assume that the 7 000 ha of JSP sugar cane and 2 300 ha of bananas need at least 1 l/s for irrigation during the jilaal - crop requirements are particularly high in this hot season. Total requirements are thus at least, say, 10 000 l/s (10 m^3/s). Even if all the pumps along the river could extract every l/s available (this is not the case, for practical engineering reasons) there would be several weeks of inadequate water availability. This supports the banana farmers' and JSP's contention that they suffer from water shortages in most jilaal seasons.

Figure 2.5

1985/86 Jilaal Season
Discharges at Mareerey



CHAPTER 3

FUTURE SITUATION

3.1 Effects of Bardheere Dam on the Juba River Regime

In its natural state, the Juba tends to be either in low flow or high flow. By contrast, the proposed dam would produce a flow regime varying quite closely around the annual mean (Table 3.1). Harmful flooding would be limited to all but the rarest occurrences and low flows could be maintained to meet all foreseeable irrigation demands.

TABLE 3.1

Juba River At Bardheere
Distribution of Mean Monthly Flows

Flow (m^3/s)	Frequency of Occurrence (%) Natural Regime	Dam Releases
0 - 100	34	0.5
100 - 200	19	81.5
200 - 300	24	8
300 - 400	11	4
400 - 500	7	3
500 - 600	3	2
> 600	2	1

Electricity generation will provide the main benefit of Bardheere Dam and this has been the prime consideration in the design of the dam and its operating rules. The dam will also have a river regulation function, and to prevent downstream flooding releases from the dam will only exceed 700 m^3/s for the 1 in 100 year event. As releases of less than 700 m^3/s would produce little damage and releases above 700 m^3/s have such a low probability of occurrence, it can be assumed that the Bardheere Dam will reduce flood damage to insignificant levels. The flood control benefits accruing from the dam will therefore be equal to the average annual cost of damage caused by the flooding of the river in its natural state.

The operating rules for Bardheere Dam given by Electroconsult in its 1986 Design Report have been developed, first, to maximise electricity generation and, second, to prevent downstream flooding. Downstream irrigation requirements (excluding desheks) have also been considered on a monthly volume basis. The basic operating criteria adopted by Electroconsult are:

(i) The level in the reservoir should not drop below that necessary to pass the minimum required flow of 135 m^3/s through the turbines.

(ii) Downstream releases in excess of 700 m^3/s should have a return period of 1 in 100 years.

(iii) Downstream irrigation requirements should be met for about 93% of the year.

Electroconsult has developed a computer program to simulate dam operation, but this is on a monthly basis and no details of how daily releases would be determined are given. Examination of the results of the simulation shows that, for most months of the year, inflow is equal to outflow, subject to the minimum turbine requirement of 135 m^3/s.

At monthly inflows greater than 700 m^3/s outflows are limited to 700 m^3/s by increasing reservoir storage. Excessive reservoir levels eventually require releases to be raised above 700 m^3/s (thus causing flooding downstream) once every 100 years).

In terms of meeting irrigation requirements these operating rules would appear to have two limitations:

(i) By generally setting the monthly outflow equal to the monthly inflow, valuable irrigation water is lost. Subject to available storage, this water could be retained in the reservoir and used to meet downstream requirements for more than the 93% of the year as originally proposed.

(ii) Simulation on a monthly basis does not allow an assessment of the effect on deshek cultivation to be made. The flow at which the desheks can be flooded has not been determined but is likely to be in the range 600 to 700 m^3/s for most desheks. On a monthly basis this outflow would have a return period of 5 to 10 years, which implies that flooding of the desheks is not feasible. If, however, outflow is considered on a daily basis then it should be possible to arrange for flows of 600 to 700 m^3/s to be released for part of the month at the critical gu and der planting times, so that controlled flooding of the desheks could be achieved.

Assessment of Bardheere benefits would need to take account of likely future trends in 'without Bardheere' river flows if these were expected to differ significantly from the present regime. Many rivers in Africa are experiencing a progressive increase in peak flood flows and reduction in base flows, due to deforestation and other damage in their catchments. Another possible problem for the Juba might be increased water use upstream in Ethiopia. This could have a serious effect on the level of dry season river flows reaching Somalia.

We understand, however, that neither upper catchment deterioration nor upstream diversions are likely to be problems for the Juba. The upper catchment is located in a remote and under-populated part of Ethiopia, with limited agricultural potential, so major changes in catchment land use are not expected. In its 1978 Bardheere Reservoir Review MMP made an assessment of the availability of irrigable land in the upper catchment of the valley by means of a LANDSAT image interpretation. The conclusion reached was that there is, at most, some 60 000 ha of irrigable land suitable for development. Nevertheless, in order to verify this in more detail, a study has been commissioned to update the 1978 MMP assessment of potential upstream water use in Ethiopia.

3.2 The Agricultural Impact of Bardheere Dan

Bardheere Dam will eliminate Juba river flooding, the problem of low jilaal flows, and also the high river water salinity levels at the start of the gu season and the intrusion of sea water as far upstream as Kamsuuma which sometimes occurs in the jilaal season. The agricultural and related effects of these changes can be summarised as follows:

(i) River flood damage to irrigated and rainfed agriculture and other activities and facilities will no longer occur.

(ii) Crop yields and cropping intensities on existing irrigated lands may increase, due to the removal of the jilaal water availability constraint and the river water salinity problem.

(iii) A major expansion of irrigation will become possible, including both perennial and annual crops.

(iv) Flooding of the reservoir area (32 000 ha) will result in some reduction of output from small-scale pump irrigation, livestock grazing and, possibly, rainfed farming. On the other hand, fish production from the new reservoir could become significant.

Valuation of these benefits and disbenefits is the main purpose of this part of the study and is described in detail in Chapters 4 to 8. Sections 3.4 to 3.5 discuss future irrigation development with and without the dam, since the differences between the two will form the basis of the irrigation benefit assessment.

3.3 Environmental and Socio-Economic Impact

The likely environmental and socio-economic impact of the dam is under study by JESS and its findings will not become available for some time. Informal discussions with JESS staff suggest, however, that the environmental impact will be less than with most dams of this magnitude. Effects on wildlife would be negligible since, according to the 1984 Southern Rangelands Survey, the wildlife population density in the reservoir area is very low. There are few, if any, major areas of forest which would be submerged. Seasonal livestock movements will be disrupted, because at present the nomads and their animals congregate in and around the riverain belt in the jilaal, but they will still have adequate access to water in the future, along the shores of the new lake. Seasonal fluctuations in lake levels may also produce areas of good seasonal grazing along the shore.

Changes in the annual flow regime downstream of the dam will reduce seasonal flooding and may therefore affect fish production and bird and other wildlife populations. Fishing is, however, not a major industry and any economic losses caused by the reduction of seasonal flooding are likely to be small in comparison with the overall benefits of flood control.

3.4 Future Irrigation Development Without Bardheere Dam

3.4.1 Introduction

Present irrigated areas in the valley downstream of the dam site are estimated to be as follows:

	Irrigable area (ha)*
Juba Sugar Project	7 365
Mogambo Irrigation Project	2 215
Fanoole State Farm Project	1 600
Banana farms in the Lower Juba	3 315 (2 276 ha of bananas)
Small-scale private pump irrigation	1 730
	16 225

* The area with irrigation infrastructure and available for cropping.

The total irrigated area downstream of the dam site is thus some 16 000 ha, of which about 70% is in the public sector and 30% in the private sector. Estimation of the area of small-scale private pump irrigation is based on a total of 288 working pumps (the JESS September 1986 total of 408 below the dam site, minus the 120 on banana farms), and an average irrigated area of 6 ha, estimated in AHT's 1984 survey.

Projections of future irrigated areas with and without Bardheere have been made for 1995, the year of the dam's commissioning, and 2 005. Inevitably, formulation of the projections involves a considerable degree of judgement, but they are considered to provide a reasonable basis for the benefit assessment.

3.4.2 Fanoole State Farm Project

A key factor in predicting irrigation development trends pre-Bardheere is the future expansion of the Fanoole project. Fanoole is the most upstream of all the major irrigation users and, with its barrage, has the ability to divert as much of the jilaal flows as it wants, within the limitations imposed by the capacity of its main canal (33.6 m^3/s). In most years any additional diversion of jilaal flows by Fanoole will have a direct adverse impact on downstream users, especially the banana farms. This has happened on occasions in the recent past. Nevertheless, the assumption made is that, as a result of the pressure of demand from existing downstream users, Fanoole's future jilaal abstractions will not increase without Bardheere.

Fanoole has suffered from substantial input supply and management problems, which are reflected in the present relatively low annual cropping intensity of 80 to 90%. For analysis purposes it is assumed that in the future these problems will be resolved to some extent and that intensities will reach 100%, split equally between the gu and der rice crops (i.e. a seasonal cropping intensity of 50%).

Progress so far with Fanoole development has been slow, with only 1 600 ha being developed over the past 12 years. Although the Chinese, as well as the Somali Government, has devoted considerable manpower and funds to the project, a major increase in the rate of development may be difficult to achieve. Future plans for the project are uncertain. According to staff at the project site, four construction phases are envisaged, each covering two of the eight branch (secondary) canals. Other at the MOA consider that the first priority must be to utilise more fully the existing irrigated land before attempting any expansion; this seems entirely sensible. Clearly, the project has major problems and, until these are resolved, there is little point in rapidly extending the irrigated area.

Given the uncertainties involved, it is difficult to make a reliable forecast of the future irrigated area without Bardheere. To provide some basis for assessing BDP benefits, however, the assumption made is that there will be some gradual expansion in the next eight years up to 1995, up to 4 000 ha, just over half the originally planned area of 7 750 ha, but no further expansion thereafter. Since Fanoole's problems are not due primarily to flooding or the availability of water or pumping energy, Bardheere would not directly bring about a significant increase in the project's irrigated area.

3.4.3 Mogambo Irrigation Project

By 1995 MIP Phase 1 (2 215 ha) should have reached the full cropping intensity which it is considered likely to achieve without Bardheere, namely 170% on both the 2 052 ha of rice land and the 163 ha under sprinkler irrigation.

Under present plans MIP Phase II would cover some 3 050 ha. Phase IIA (1 170 ha) comprises 790 ha of basin soils, best suited to rice, and 380 ha of levee soils suitable for mixed cropping. The assumption is that Phase IIA would be constructed in 1992-1993, irrigated cropping beginning in 1993, but that Phase IIB would not be built without Bardheere. Phase IIB would comprise 1 900 ha of sprinkler irrigation (its soils are not suitable for gravity irrigation). Cropping intensities on the MIP Phase IIA area would be similar to those on Phase I.

3.4.4 Juba Sugar Project

Phase II of Juba Sugar Project (6 300 ha) would not be implemented without Bardheere, because of its large size and thus high water requirements. Crop yields on the Phase I area would continue to be adversely affected by water shortages resulting from the periodic lack of fuel for sprinkler irrigation pumping (provision of hydro-electricity from Bardheere for all pumping should overcome this constraint) and the low jilaal river flows.

3.4.5 Banana Farms in the Lower Juba

The current banana area is 2 276 ha on an irrigable area of 3 315 ha, the cropping intensity thus being 69%. At present the area is expanding, but it seems unlikely that, with the problems of jilaal water shortage and the danger of flooding, this expansion will continue for very long. It has been assumed that the irrigable area would reach a maximum of 4 000 ha by 1990 and would remain constant thereafter. With a 75% intensity the banana area would be 3 000 ha, assuming some improvement in cultivation standards (i.e. longer plant life, so less fallow). In most years yields will be well below their potential, because of the effects of jilaal water shortages.

3.4.6 Small-Scale Pump Irrigation

Small-scale private pump irrigation has been increasing and, even without Bardheere, can be expected to continue to do so for at least the medium-term future, despite the problems of low jilaal flows, diesel fuel shortages and occasional flooding. The Government is now giving increasing emphasis to providing medium-term credit for private sector developments like pump irrigation. Some desheks in the Middle and Lower Juba valleys are being partly or wholly converted to private irrigation. Merchants and other entrepreneurs have begun to invest in pumpsets, with local farmers using the pumped water on a crop sharing basis.

Experience in other countries, such as along the Nile in Sudan, has shown that pump irrigation can expand very rapidly. As a rough estimate the assumption made is that development would accelerate in the immediate future to a rate of 200 ha per annum (just over 10% of the existing area of 1 730 ha) up to 2005, after which the 'without Bardheere' constraints of poor road access, low jilaal flows and periodic flooding would prevent further expansion. The total area of small-scale pump irrigation would thus reach 5 330 ha (18 years x 200 ha, plus the existing 1 730 ha) by 2005. This would include any rehabilitation of the abandoned co-operative schemes (see Section 2.9) that may be carried out.

In the past, cropping has been concentrated particularly on onions and other vegetables, tobacco and other high value crops, but field crops like maize and sesame are now being more widely grown. Market demand would probably be insufficient to support over 5 000 ha of private irrigation growing mainly high value crops. For both 'with' and 'without Bardheere' situations, therefore, we have assumed that cropping would be based mainly on field crops.

3.4.7 Total Irrigated Areas Without Bardheere

Table 3.2 summarises the projected future 'without Bardheere' irrigated areas in the Juba valley below the dam site. Under these assumptions the total irrigated area would be about 22 000 ha in 1995 and 24 000 ha in 2005, after which further expansion would be negligible.

TABLE 3.2

Assumed Future Net Irrigated Areas Without Bardheere Dam (ha)

Category or Scheme	Year 1987	1995	2000	2005 onwards
Fanoole State Farm Project	1 600	4 000	4 000	4 000
Mogambo Irrigation Project	2 215	3 385	3 385	3 385
Juba Sugar Project	7 365	7 365	7 365	7 365
Lower Juba banana farms	3 315	4 000(1)	4 000	4 000
Small-scale private pump irrigation	1 730	3 330	4 330	5 330
Total	16 225	22 080	23 080	24 080

Note: (1) At 75% intensity the banana area would be 3 000 ha.

3.5 Issues and Factors Affecting Future Development

3.5.1 Introduction

Before attempting to predict the characteristics and rate of irrigation development after construction of the dam, various factors need to be considered. These include:

- feasible rates of development;
- the respective roles of the public and private sectors;
- soil quality and areas for irrigation development.

3.5.2 Farm Labour Supply

Population density in the Juba valley is not high and labour supply is a constraint on many schemes, especially in the gu season. Since cultivation using draught animals is almost unknown the consequence is that a high degree of tractor mechanisation is needed for land preparation on intensive irrigation schemes. This task is arduous and time-consuming if done by hand, and high cropping intensities would be difficult to achieve without mechanisation. It is, however, expensive in terms of both capital and recurrent costs.

3.5.3 Feasible Rates of Development

Rates of development on irrigation projects in Somalia have generally been below expectations, due particularly to foreign exchange, logistical and administrative problems. Rates achieved on Mogambo and the original construction of Afgoi-Mordile, on the Shebelle, were somewhere around 1 000 ha per annum, whereas that on Fanoole has been very much slower. Allowing for at least two projects being built at the same time, we have assumed an average construction rate of 3 000 - 3 500 ha per annum for public sector development in the valley. This is somewhat above past rates achieved but is considered to be an attainable figure.

3.5.4 The Respective Roles of the Public and Private Sectors

Future irrigation development could be undertaken by the public sector, the private sector, co-operatives or a combination of these.

As is now widely recognised, co-operatives are not a viable option for running irrigation schemes, as past experience in Somalia and many other countries shows.

At present, private irrigation in the valley comprises two distinct types, the medium-scale commercial banana growers and the small-scale pump schemes developed by farmers, merchants and others. Apart from the banana farms, there appears as yet to have been little of the medium-scale pump irrigation by private entrepreneurs which has occurred along the Shebelle in recent years. Construction of Bardheere Dam, with the consequent improvement of the river regime and roads and the ready availability of hydro-electricity, can, however, be expected to stimulate such development. Most schemes of this type would be fairly small, rarely exceeding 100 ha, especially as the most suitable land, the levee soils along the river, occurs in fairly narrow strips. Much of that in the Lower Juba is already occupied by the banana farms.

The scope for much larger privately-financed irrigation developments is very limited. At present, few, if any, Somali companies and entrepreneurs have both the resources and the commercial farming skills and experience to implement such projects. It would be difficult to attract suitable foreign companies because of the uncertainties and risks involved. We have assumed, therefore, that all large-scale projects (say, those over 1 000 ha) would be government-financed and run.

In predicting future irrigation development with Bardheere, we have given considerable emphasis to private irrigation, for the following reasons:

- Private development does not require any direct government involvement and is thus not vulnerable to the constraints of recurrent cost funding and government implementation capacity.

- Much of the irrigable land in the valley is located near the river in parcels which are too small to justify development as a government scheme, yet are well-suited to smaller-scale irrigation by private individuals.

- Such schemes can be very profitable, because their capital and running costs per ha are low.

- The success of the banana farming sector, despite flooding and water shortages, demonstrates the practical feasibility of this form of development.

We envisage, therefore, a post-Bardheere irrigation programme based on a combination of both government and private sector development.

3.5.5 Soil Quality and Areas for Irrigation Development

In their 1984 report on Deshek and Small and Medium-scale Irrigated Agriculture, AHT prepared a very useful physiographic and land use map for the whole of the Juba flood plain and the adjacent areas, using aerial photo-interpretation. Although no soils and land classification was attempted this does provide some indication of irrigability.

Within the floodplain itself the levee category has the highest potential, though mainly for small and medium-scale irrigation. Many of the adjoining parts of the 'Flat Flood Plain' should also have potential, as should the higher parts of the desheks.

Another major category which appears to be suitable is the 'Heterogeneous Alluvial Sediments', which occur downstream of Kamsuuma. Mogambo Project is located mainly on these soils. Much, if not most, of this land has heavy cracking vertisolic clays. Despite their apparent poor internal drainage, high alkalinity and other problems, experience with these soils in the irrigated schemes of the Sudan and other countries has shown that they can be highly productive under irrigation. Fears of a buildup of water-table levels and soil salinity have often been exaggerated. Sudanese experience with irrigation on well over one million hectares of such land suggests that these problems do not necessarily affect it substantially. According to Annex 3 of the AHT report there are some 26 000 ha of such land in the Lower Juba.

Some idea of the potential for small and medium-scale irrigation can be obtained from the AHT figures for Levee, Flat Floodplain and Deshek land per District. Table 3.3 presents the figures shown in the AHT report.

TABLE 3.3

Levee, Flat Floodplain and Deshek Land per District (ha)(1)

District	Levee	Flat Floodplain	Deshek	Total
Bardheere	1 350	1 406	-	2 756
Saakow	1 594	-	1 917	3 511
Bu'aale	4 182	-	11 366	15 548
Jilib	1 459	2 615	1 789	5 863
Jamaame/Kismayo	3 373	7 159	5 535	16 067
Total	11 958	11 180	20 607	43 745

Note: (1) These figures exclude all existing and abandoned banana land and the land occupied by the Juba Sugar, Mogambo and Fanoole projects.

Source: AHT, 1984

Much of the 12 000 ha of Levee land would probably be suitable for private irrigation. This may also be the case with the Flat Floodplain, except that some is too far from the river for private irrigators. Much of the deshek land may also not be suitable, being too low-lying or too far from the river.

Until the results of the USBR analysis of land suitability become available, the area of land which might be developed under private irrigation cannot be quantified in any detail. Nevertheless, based on the figures in Table 3.3 concerning the areas of each type of land, it seems probable that the potential area would be at least 15 000 ha.

3.6 Future Irrigation Development with Bardheere Dam

3.6.1 General

Apart from providing an assured supply of irrigation water and the elimination of flooding, Bardheere dam will accelerate the rate of development through the supply of hydro-electricity for pumping, greatly improved road access to the riverain zone between Jilib and the dam site, and the general impetus which construction of the dam will give to regional economic growth. Electric pumping is cheaper and more convenient than the diesel pumping which it will replace. Experience with rural electrification, especially in Asia, shows that it often results in a marked acceleration in the rate of irrigation development, for this reason.

3.6.2 Public Sector Development

Our projections for the 1995 to 2005 period are based on the following assumptions:

(a) Bardheere dam becomes operational in the gu season of 1995.

(b) For the main analysis, construction rates, in terms of the total new area being made available for irrigated cropping, would not normally exceed 3 000 ha per annum except when JSP II is being developed. A rapid build-up of crop area is essential on a sugar project, to increase factory utilisation as rapidly as possible, and the speed of construction achieved on JSP I was relatively high.

(c) Fanoole project would not expand beyond the area of 4 000 ha reached in 1994.

(d) The Smallholder Banana Pilot Project (500 ha) would come into operation in 1995.

(e) The Homboy project would be constructed between 1993 and 1998.

(f) Due to uncertainties as to its economic viability, Mogambo IIB has been grouped with Unidentified New Projects. Construction of such projects would begin in 1999 and thereafter continue at the rate of 3 000 ha per annum.

Table 3.4 shows a possible development programme based on these assumptions. This is indicative in nature and is not intended as a definitive programme. The figures shown represent the number of hectares brought under irrigation each year.

TABLE 3.4

Possible Public Irrigation Development Programme with Bardheere Dam, 1995 to 2005 (ha)(1)

Year	Smallholder Banana Scheme	Homboy	JSP II	Mogambo II and new unidentified projects	Total
1995	500	2 000	1 000	-	3 500
1996	-	2 000	1 500	-	3 500
1997	-	2 000	1 500	-	3 500
1998	-	2 000	1 500	-	3 500
1999	-	850	800	1 350	3 000
2000	-	-	-	3 000	3 000
2001	-	-	-	3 000	3 000
2002	-	-	-	3 000	3 000
2003	-	-	-	3 000	3 000
2004	-	-	-	3 000	3 000
2005	-	-	-	3 000	3 000
Total	500	8 850	6 300	19 350	35 000

Note: (1) No further expansion of Fanoole project is envisaged after 1994.

Under these assumptions, some 35 000 ha would be brought into operation as government schemes between 1995 and 2005.

3.6.3 The Lower Juba Banana Farms

Bardheere can be expected to result in a rapid expansion in banana areas and substantial yield improvements. It is estimated that the long-term export market potential is sufficient to support a total of up to 8 000 ha of bananas in the Lower Juba. Allowing for the 2 800 ha proposed for the smallholder pilot scheme and Homboy (on 3 500 ha total area, i.e. 20% fallow) and the 3 000 ha on existing farms already in operation by 1990, an expansion of 2 200 ha (2 930 ha net irrigable area, assuming 75% banana intensity on private banana farms) due to Bardheere has been assumed. This development would take place over five years at an average rate of 440 ha (just under 600 ha net irrigable area) per annum. Most of the increase would probably be intensification on existing farms and rehabilitation of abandoned farms, rather than the development of new areas.

3.6.4 Other Private Pump Irrigation

Without Bardheere an expansion in other private pump irrigation schemes from 3 330 ha in 1995 to 5 330 ha in 2005 was predicted (Table 3.2). The brief analysis made in Section 3.4.5 suggests that as much as 15 000 ha or more may be suitable for private development. Some of this would be in medium rather than small-scale schemes, because of distance from the river and other factors. For example, the private sector may be able to rehabilitate many of the 27 abandoned co-operative schemes but, since most are over 100 ha in size, this would be a medium rather than small-scale development.

It is not possible to forecast with any assurance how rapidly private pump irrigation would expand. As a broad assumption, however, a rate of expansion of 1 000 ha per annum has been taken for the 1995 to 2005 period. The total area would thus reach 14 130 ha in 2005.

3.6.5 Total Irrigated Areas with Bardheere Dam

Table 3.5 shows the total irrigated area with Bardheere assumed for 1995, 2000 and 2005, and the increase in area due to the dam. These figures do not include the possible development of controlled flooding of desheks.

TABLE 3.5

Assumed Total Irrigated Areas with Bardheere Dam (ha)

	1995	2000	2005
Without Bardheere (based on Table 3.2)	22 080	23 080	24 080
With Bardheere			
Existing government schemes	14 750	14 750	14 750
New government schemes	3 500	20 000	35 000
Lower Juba banana farms	4 600	6 930	6 930
Other private pump irrigation	4 130	9 130	14 130
Total	26 980	50 810	70 810
Increase due to Bardheere	4 900	27 730	46 730

According to these projections, the total irrigated area would be some 71 000 ha and the assumed increase in irrigated area due to Bardheere would be about 47 000 ha. Expansion would of course continue thereafter. Based on the figures shown for years 2000 and 2005 in Table 3.5, the annual rate of increase might be between 3 000 ha and 4 000 ha, although this would eventually slow down somewhat, as most of the land suitable for private irrigation is developed.

3.7 Future Cropping Patterns

To provide the basis for estimating BDP agricultural benefits, including those from preventing flood damage to crops, forecasts of likely future cropping patterns with and without Bardheere have been made (Table 3.6). It should be emphasised that these are only predictions and that, in practice, cropping patterns will vary considerably according to the soils and other characteristics of each scheme, market conditions, farmers' preferences and numerous other factors.

The basic assumptions on which the projections are based are as follows:

(a) By making reliable supplies of irrigation water and pumping energy (electricity) available throughout the year, Bardheere will enable farmers and schemes to increase annual cropping intensities substantially above 'without Bardheere' levels. Double cropping, which is already achieved by many farmers, even under rainfed and deshek cropping, would become the norm. Provision of reliable jilaal flows will extend the irrigation season for most farmers by at least one month, thus making double cropping easier to achieve.

(b) Two main cropping patterns would be followed on government schemes, double cropping of rice on the heavier soils and double cropping of mixed crops (mixed arable cropping) elsewhere. The mixed arable cropping pattern would be that proposed for the Homboy Irrigation Project (see Annex 1) and would be based on crops which are already grown in the Juba valley. Although rice double-cropping has not yet been achieved on schemes like Mogambo, it is expected that solutions to the problems of heavy weed infestation in the gu season, bird damage, etc. will eventually be found. Double cropping of rice is practised in many parts of the tropics and there seems little reason why it should not eventually be adopted in the Lower Juba valley.

(c) Small scale private pump irrigators would grow a wide range of crops, including paddy rice 'with Bardheere' (paddy rice is grown by irrigators along the Shebelle) but with a much lower percentage (10% to 15%) of vegetables and other high value crops than at present, due to market constraints.

(d) As at present, rainfed and deshek cropping would be based on traditional crops like maize, sesame and pulses. The intensities shown are in terms of harvested rather than planted hectares and thus allow for crop failures, which are caused primarily by lack of moisture.

(e) Bananas and sugar cane would continue to be the main perennial crops. Market prospects preclude the large-scale production of other perennial crops (e.g. grapefruit) in the near future (see Annex 1).

TABLE 3.6

Assumed Annual Cropping Patterns and Intensities for Annual Crops (%)

Scheme	Gu season Rice	Maize	Sesame	Pulses	Vege-tables	Total	Der season Rice	Maize	Sorghum	Sesame	Pulses	Cotton	Vege-tables	Total	Annual Intensity
1. Homboy new unidentified Government projects and Mogambo IIB															
- Rice area	100	-	-	-	-	100	100	-	-	-	-	-	-	100	200
- Mixed arable cropping	-	60	-	36	4	100	-	-	-	48	-	48	4	100	200
2. Mogambo I and IIA															
(a) Without Bardheere															
- Rice area	100	-	-	-	-	100	70	-	-	-	-	-	-	70	170
- Other areas	-	51	-	31	3	85	-	-	-	41	-	41	3	85	170
(b) With Bardheere															
- Rice area	100	-	-	-	-	100	100	-	-	-	-	-	-	100	200
- Other areas	-	60	-	36	4	100	-	-	-	48	-	48	4	100	200
3. Fanoole Rice Project															
- Without Bardheere	50	-	-	-	-	50	50	-	-	-	-	-	-	50	100
- With Bardheere	65	-	-	-	-	65	65	-	-	-	-	-	-	65	130
4. Small-scale private pump irrigation															
- Without Bardheere	-	60	20	10	10(1)	100	-	30	-	50	10	-	10(1)	100	200
- With Bardheere	10	60	20	10	15(1)	115	-	30	-	50	10	-	25(1)	115	230(2)
5. Fallow areas on private banana farms	-	85	-	-	-	85	-	-	-	40	-	-	-	40	125
6. Deshek cultivation(3)	-	85	15	-	-	100	-	35	-	65	-	-	-	100	na
7. Rainfed cropping in the Lower Juba(4)	-	60	30	-	-	90	-	-	25	10	-	-	-	35	125

Notes:
(1) These include tobacco, water melons and other minor crops as well as vegetables.
(2) This assumes some cropping in the xagaa and jilaal seasons.
(3) Percentage of deshek cropped area, which varies from season to season.
(4) These figures are for harvested areas, not planted areas, and therefore allow for crop failure. The deshek cropping pattern is based on the averages for Jilib, Bu'aale and Saakow districts calculated from the AHT, 1985, Deshek Report. Deshek crop failures are taken as 25% of the total planted area, the failures being caused mainly by post-planting flooding and lack of moisture.

3.8 Future Crop Yields

Table 3.7 shows the crop yields assumed. The rationale behind the individual projections is given in Annex 1 and, in the case of JSP sugar cane, in Section 6.1. Rainfed and deshek yields are for crops harvested and thus exclude crop failures. In general, Bardheere's main effects on crop production are expected to be more on cropping intensities (Table 3.7) than on crop yields. The implicit assumption is that in the 'without Bardheere' situation farmers and projects will reduce their crop areas if they expect significant shortages of jilaal water or diesel pumping fuel, rather than deliberately planting larger areas and thereby risking substantial yield losses.

In general, the yields for government projects are from the upper ranges of what is achieved at present. The projected yields represent what is expected to be achieved in the medium- and long-term future, since even the beginning of the analysis period (1995) is eight years from now. It is, therefore, reasonable to predict significant improvements over present yields.

3.9 Impact of Bardheere Dam on Deshek Flood Recession Cropping

In the past three years considerable attention has been given to the desheks and their future with and without Bardheere. During this period, however, considerable changes in the use of desheks have taken place and, as a result, traditional flood-recession is now less important than was previously thought to be the case. According to AHT, most are now bunded to exclude flooding and rely mainly on rainfall for their cropping. Considerable development of pump irrigation of the jiimo land adjacent to the desheks and of the desheks themselves is also taking place. The conversion from flood recession to rainfed cropping has been encouraged by the good rains in the past 2 to 3 years, which have made the use of flooding less necessary for crop production.

As described in Section 2.3, there are less than 5 000 ha under traditional deshek cropping. Table 3.8 shows the AHT estimated return periods for deshek flooding on the areas in each district.

TABLE 3.8

Percentage of Deshek Cultivated Areas Flooded for Various Return Periods

District	Return period (years)	Gu season 1-2	Gu season 3-4	Gu season 5 and over	Der season 1-2	Der season 3-4	Der season 5 and over
Saakow		48	18	34	100	-	-
Bu'aale		65	29	6	100	-	-
Jilib		34	-	66	34	-	66

Source: AHT October 1986 Deshek Report, Annex 4, Tables 2,3 and 4.

TABLE 3.7

Assumed Crop Yields (t/ha)

	Sugar cane per annum(1)	Bananas export quality	Bananas local market quality	Rice	Maize	Sorg-hum	Sesame	Pulses	Seed cotton	Vege-tables
Homboy, new Government projects, Mogambo	-	19.75	5.0	4.00	3.00	-	0.60	0.75	1.50	7.0 (onions)
Fanoole Rice project	-	-	-	4.00	-	-	-	-	-	-
Small-scale private pump irrigation	-	-	-	3.00	2.25	-	0.45	0.5	-	5.0
Deshek cultivation	-	-	-	-	0.80	-	0.25	-	-	-
Rainfed cropping in the Lower Juba:										
- Gu	-	-	-	-	0.80	-	0.30	-	-	-
- Der	-	-	-	-	0.50	0.60	0.20	-	-	-
Juba Sugar Project I										
- without Bardheere	78.2	-	-	-	-	-	-	-	-	-
- with Bardheere	102.4	-	-	-	-	-	-	-	-	-
(JSP II yield the same)										
Private banana farms	-	19.75	5.0	-	2.25	-	0.45	-	-	-

Notes: (1) This is an overall average for plant crops and ratoons and is the yield for the total area of sugar cane on an estate allowing for the 2½% of the area used for the production of seed cane; i.e. it does not contribute directly to the estate's sugar output.

(2) This is the annual average yield over the life of a banana crop. Year-by-year yields during a banana plant's life vary widely, according to age.

From the viewpoint of calculating crop areas in the average year it could be assumed, for the sake of simplicity, that average annual crop areas in desheks flooded only one year in five or more years are insignificant, as they are so rarely cropped. If one then takes the mid-point of each remaining return period range (e.g. 1.5 years for the 1-2 year range) the average annual crop areas by season would be as follows, based on the district cultivated areas given above:

District	Cultivated area (ha)	Gu season		Der season	
		Return period (years)			
		1.5	3.5	1.5	3.5
Saakow	1 050	504	189	1 050	-
Bu'aale	2 420	1 573	702	2 420	-
Jilib	1 400	476	924	476	924

Based on these areas and return periods, the average annual cropped areas would be as follows, in hectares:

District	Gu	Der	Total
Saakow	390	1 090	1 480
Bu'aale	1 250	1 610	2 860
Jilib	581	581	1 162
Total	2 221	3 281	5 502

These estimates suggest that the annual cropped area under flood recession cultivation averages 5 to 6 000 ha, of which 40% is in the gu and 60% in the der. In each season a substantial proportion of the cropped hectares would not produce a harvestable crop, due to crop failure caused by lack of moisture after the exhaustion of the reserves left by flooding, and damage resulting from subsequent unexpected floods. One would expect the crop failure rate to be at least, say, 20%, in which case the average harvested area could be taken as 4 000 to 5 000 ha, say, 4 500 ha, of crop.

Bardheere could have two main effects on deshek cropping:

1. By greatly reducing annual flood peaks, it could eliminate or reduce deshek flooding and thus flood-recession cropping.

2. By maintaining substantial river flows throughout the year it might hinder the drainage of desheks in the dry season and might also result in a rise in groundwater tables in the desheks, so that their lower parts would become permanently flooded.

The likelihood of major permanent flooding seems slight. River discharges after Bardheere's construction will generally vary between 150 m^3/s and 350 m^3/s. At 200 m^3/s there appears to be only some 1 m difference in level between the river water level and the lowest parts of the desheks. In AHT's sample of five desheks for detailed study these low areas were usually at least 0.5 to 1.0 km from the river. With this distance, the hydraulic gradient between the river and deshek would almost certainly be insufficient to result in a build-up in water-tables to above the ground surface.

Bardheere need not eliminate deshek flooding, because artificial flood waves could be created by controlled releases from the reservoir. AHT analysed the scope for doing this in their 1986 deshek report. Based on AHT and other data, we have analysed this further, the details being given in Appendix B. The conclusions reached in Appendix B can be summarised as follows:

(a) In the der season controlled flooding of the desheks would be possible in approximately 75% of the years, which represents a slight reduction from the present (without Bardheere) frequency of flooding. Since the average annual flood-cropped area in the der season is only some 3 300 ha the overall effects on crop output would be small.

(b) Controlled flooding in the gu season would normally not be possible, because the release of reservoir water would reduce that available for power generation to below that required to meet the firm power demand (135 m^3/s). Some 2 200 ha of flood recession gu cropping would thus be lost.

Based on these figures, the total loss of flood-recession crop output would not exceed 3 000 ha. Since the main loss would be in the gu season, which is the period of heaviest rainfall and the principal rainfed cropping season, much, if not most, of the land currently under flood-recession cropping would be cropped under rainfall. Parts of the desheks would also be converted to private pump irrigation. Taking account of both these factors, the net losses in crop production are considered to be too small and uncertain to warrant inclusion in the economic analysis as disbenefits of the BDP.

3.10 Flooding of the Reservoir Area

Reservoir flooding will result in the loss of irrigated crop land and livestock grazing (the area of rainfed cropping is negligible). On the other hand, some cropping on residual moisture may develop on the fringes of the lake, to take advantage of seasonal rises and falls in water levels.

The most serious negative effect of the reservoir flooding will probably be the loss of up to 200 km of the alluvial strip along the river. Although the total amount of land involved is not great, it contains a substantial amount of private pump irrigation. In late 1986 there were 95 pumpsets in operation which, assuming an average of 6 ha of irrigation per pumpset, implies a total irrigated area of 570 ha. This was one of the first parts of the Valley to develop small-scale pump irrigation and the scope for further expansion is probably limited by road access, the limited area of irrigable land and the fact that much of this land has already been developed. Annual percentage rates of expansion are therefore expected to be less than for the Valley as a whole (see Section 3.4.6). The assumption made is that private pump irrigation in the reservoir area will increase by 30 ha (about 5% of the present area) per annum up to a maximum of 810 ha in 1995, by which time the potential will be fully utilised and no further growth will take place.

The productivity of land outside the alluvial strip is very low. Rainfed crop production is limited by the low rainfall and the main activity is livestock grazing. Livestock densities recorded for the riverine zone and its environs in the Southern Rangeland Survey are shown in Table 3.9.

TABLE 3.9

Livestock Densities

	November - December 1983 (wet season)	March 1984 (dry season)
Cattle	8 - 16/km^2	8 - 16/km^2
Camels	zero	20 - 30/km^2
Sheep	16 - 32/km^2	16 - 32/km^2
Goats	40 - 60/km^2	60 - 80/km^2
Total biomass	8 000 - 12 000 kg/km^2	Over 16 000 kg/km^2

The main reason for the higher livestock density in the dry season is presumably the ready access to water in the river. The lake would fulfil the same function in the future. From the viewpoint of quantifying the value of grazing land lost, the wet season population figure is therefore more valid. With an inundated area of 32 000 ha (that covered at Maximum Normal Water Level), the biomass carrying capacity lost would be 2.6 to 3.8 million kg, which at 250 kg per head is 10 000 to 15 000 cattle-equivalents.

CHAPTER 4

BENEFIT CATEGORIES AND THEIR VALUATION

4.1 Benefit Categories

The main types of agriculture and flood control benefits from Bardheere Dam will include:

(i) Increased irrigated crop and livestock production resulting from:

(a) the expansion of irrigated land in the valley, including extensions to existing government schemes, construction of new government schemes and the expansion of banana farms and other types of scheme using private pump irrigation;

(b) intensification of cropping on existing government and private schemes due to improved jilaal river water availability and the more reliable supply of pumping energy, hydro-electricity replacing diesel fuel as the source of pumping power on most large and medium-sized schemes.

(c) crop yield improvements on some existing schemes, due to improved jilaal water availability and the elimination of the problems of saline intrusion in the lower Juba and the high salinity of the early gu river flows.

(ii) The reduction in crop production losses, infrastructure damage, transport and economic disruption and other adverse consequences of Juba river flooding.

(iii) Some reduction in irrigation pump station operation and maintenance costs for existing (i.e. without Bardheere) schemes, resulting from the conversion from diesel to electric pumping on the large- and medium-scale schemes. It is considered unlikely that many of the small scale schemes would be converted to electric pumps in the near future. Savings in energy costs will already be taken into account in the dam's hydro-electric benefits, but there will be other savings in motor capital and maintenance costs and other items, as a result of the conversion to electric pumping.

Against these benefits should be set the agricultural cost of reservoir flooding, in terms of the loss of irrigated and rainfed crop land and livestock grazing land. Some of this loss might be offset by fisheries production in the reservoir and the development of flood-recession cropping on its margins.

Benefits from the construction of a Jilib to Bardheere road have not been quantified in this study.

4.2 Methodology

4.2.1 General

The approach has been to formulate a year-by-year stream of benefits and costs at the two price scenarios (see Section 1.4) which can then be used for the overall economic analysis of Bardheere dam. The benefits would comprise the categories listed in Section 4.1 and the costs would include:

- capital and recurrent costs of new irrigation development (see Benefit Category (i)(a) above);

- the increase in recurrent costs resulting from cropping intensification on existing schemes (see Benefit Category (i)(b));

- the cost of increased pumping required to obtain the yield benefits from better jilaal water availability (Benefit Category (i)(c);

- the costs of electricity distribution to serve the existing schemes which would change over from diesel to electric pumping, with an appropriate deduction to take account of the benefits to other users from making electricity available:

- other costs of converting from diesel to electric pumping on existing schemes.

The costs of reservoir flooding have been included in the benefit estimates as a deduction made to arrive at the net benefits.

Irrigation and other developments based on the dam will continue for many years to come. A relatively long analysis period of 40 years following the commissioning of the dam in 1994/1995 has therefore been adopted. Detailed benefit estimates have been made for the 1995 to 2005 period and then used as the basis for less detailed projections from 2006 to 2034. All costs are in 1987 constant prices (i.e. excluding the effects of future inflation). Benefits and costs have been discounted back to their present worth in 1994, the year before the dam comes on stream.

The value of rainfed crop output and livestock production lost through the conversion of land to irrigation is assumed to be taken fully into account through the application of the labour economic price (opportunity cost, see Section 4.2.2) to all irrigated crop labour inputs, both family and hired. At present, the main occupation of the rural labour force in the valley is in rainfed cropping and livestock production, the net output value of which can be considered to be reflected in the prevailing rural wage rates.

4.2.2 Economic Prices

Economic rather than financial prices have been used, following the methodology normally employed by IBRD and other agencies. A detailed explanation of the economic pricing is given in Annex 1 for the Homboy Project, and the same values have been used here.

In view of the shortage of foreign exchange in the Somali economy, a foreign exchange shadow price has been applied. On the basis of the current Official Government exhange rate of about SoSh 90/US dollar and the Commercial Bank rate a shadow price of 1.5 times (SoSh 135/US$1) the Official rate has been applied. In general the foreign exhange (FE) shadow price has been applied only to direct FE benefits and costs.

Economic prices of farm labour have been based, as far as possible, on local wage rates in the valley, since these vary markedly by season and can thus be considered to represent quite realistically the opportunity cost of labour at different times of the year. The rates assumed are SoSh 145/labour day in the gu season and SoSh 80/day during the other seven months of the year, the annual weighted average rate being taken as SoSh 110/day. The opportunity cost of capital has been assumed to be 10% (real interest rate, excluding inflation).

Table 4.1 shows the economic prices assumed under the two price scenarios. On the basis of the October 1986 IBRD Commodity Forecasts and the explanations given in Annex 1, the future prices of all inputs except seed have been taken to be the same for both scenarios. Direct FE benefits and costs in US dollar terms are presented to estimate FE net benefits and in order to facilitate subsequent recalculations if at a later date (e.g. at the BDP appraisal) a different FE shadow price has to be applied.

Electricity and fuel prices are discussed separately in Section 4.4 and livestock prices are given in Chapter 8.

4.3 Crop Net Economic Returns

Table 4.2 shows the estimated crop net economic returns and the direct FE returns in US dollars, excluding irrigation costs. Details are given in Appendix A and Annex 1.

As would be expected, net returns at High Prices are substantially higher than at Low Prices for most crops, especially rice. Normally one would expect paddy rice to be more profitable than other cereals like maize, but costs of production on large government schemes would be high because of the considerable degree of mechanisation required.

Irrigated cotton could give very attractive returns, although it should be noted that there is little experience in Somalia with well-managed irrigated cotton growing. With adequate seed quality; pest control and crop management the yield assumed, 1.5 t/ha, would not, however, be difficult to obtain. It is well below the 2 t/ha or more often achieved under irrigation in Ethiopia and Kenya.

Irrigated bananas are capable of giving very good returns because of their high yields and the good export market for Somali bananas. Achievement of the returns shown will require improvements in crop husbandry and general management on many of the existing banana farms, but the export yield assumed for the post-1995 period (19.75 t/ha annual average) is not much above the overall averages obtained in the Lower Juba valley in the early 1970s.

TABLE 4.1

Economic Prices and Direct Foreign Exchange Values of Crop Inputs and Output (SoSh at 1987 Constant Prices)

Item	Economic price with FE shadow pricing (SoSh)		Direct FE Values (US$)	
	High	Low	High	Low
1. Crops (per tonne)				
Sugar	58 200	58 200	406	406
Maize	29 200	24 800	209	176
Sorghum	27 200	23 200	195	164
Rice (unmilled)	32 200	22 300	260	183
Sesame	124 300	106 300	890[1]	754[1]
Pulses (Cowpeas)	82 800	70 800	592[1]	502[1]
Seed cotton	84 900	82 400	653	634
Vegetables (onions)	41 500	35 500	-	-
Bananas				
- Export	29 500	24 800	328	276
- Local	3 450	3 450	-	-
2. Seed (per kg)				
Maize	43.5	37.5	0.209[2]	0.176[2]
Sorghum	40.8	34.8	0.195[2]	0.164[2]
Rice	48.3	33.5	0.260[2]	0.183[2]
Sesame	186.5	159.5	0.890[2]	0.754[2]
Cowpeas	124.2	106.2	0.592[2]	0.502[2]
Cotton	99.4	99.6	0.200	0.200
Vegetables (onions)	62.3	53.3	-	-
3. Fertilisers (per kg)				
Urea		43.9		0.258
DAP		39.0		0.227
15.7.24		38.1		0.222[3]
Zinc sulphate		157.0		0.91[3]
4. Herbicides (per litre)[4]				
Stam 34		360.0		2.39

TABLE 4.1 (cont.)

Item	Economic price with FE shadow pricing (SoSh)		Direct FE Values (US$)	
	High	Low	High	Low
5. Pesticides (per kg or litre)				
Fermisan D		207.0		1.37
Bronopol dust		188.0		1.25
Diazinon		210.0		1.39
Carbofuran		318.0		2.11
Polytrin C440 EC		823.0		5.45
Malathion		260.0		1.72
Ridomi/M2 63.5%		630.0		4.18
Nuvocron		224.0		1.48
6. Labour (per labour-day)				
Gu season		145.0		-
Other months		80.0		-
Annual weighted average		110.0		-
7. Diesel Fuel (per litre)				
See Section 4.4		59.0		0.38
8. Tractor and Machinery Operations (cost per hour)(5)				
Chisel ploughing		1 950		15.4
Mouldboard ploughing		2 580		20.4
Heavy disc harrowing		2 790		22.0
Light disc harrowing		2 000		15.8
Combine drilling		3 240		25.6
Ridging		1 810		14.3
Spraying		2 600		20.5
Combine harvest		6 250		40.0
Transport by trailer:				
- General		1 960		15.5
- Grain		2 130		16.8
- Bananas		2 050		16.2

Notes:
(1) Calculated on the basis of the US$/SoSh economic price ratios for maize at High and Low prices.
(2) The same as the crop output prices.
(3) Based on the US$/SoSh ratio for DAP.
(4) Assuming an 85% FE content.
(5) Assuming the 71% FE content calculated for tractor transport with trailers.

TABLE 4.2

Crop Net Economic Returns and Direct Foreign Exchange Costs and Returns Excluding Irrigation Costs per ha at Constant 1987 Prices

Crop and yield level[1]	Economic returns (SoSh '000) High Prices	Economic returns (SoSh '000) Low Prices	Direct FE Returns (US$) High Prices	Direct FE Returns (US$) Low Prices
Paddy rice (irrigated)[2]				
Small pump schemes (3.0 t/ha)	56.8	28.4	599	374
Government schemes (3.5 t/ha)	55.7	22.5	602	340
(4.0 t/ha)	71.8	33.6	732	431
Maize				
Rainfed: (0.5 t/ha)	8.2	6.2	83	68
(0.8 t/ha)	13.4	10.2	167	141
Irrigated:				
Small pump schemes (2.25 t/ha)[2]	42.4	33.0	368	295
Government schemes (3.0 t/ha)[2]	53.0	40.5	463	365
Rainfed sorghum: (0.6 t/ha)	12.5	10.2	115	96
Sesame				
Rainfed: der (0.2 t/ha)	20.5	17.1	169	144
gu 0.3 t/ha	29.8	24.7	258	219
Irrigated:				
Small pump schemes (0.45 t/ha)	41.9	32.5	339	279
Government schemes (0.6 t/ha	52.8	42.2	409	328
Pulses (irrigated cowpeas)				
Government schemes (0.75 t/ha)	34.3	25.8	310	245
Small pump schemes (0.5 t/ha)	24.6	19.1	226	184
Cotton (irrigated)				
1.5 t/ha	81.9	78.1	779	751
Irrigated vegetables (onions)				
Small pump schemes (5.0 t/ha)	176.6	146.6	-	-
Government schemes (7.0 t/ha)	252.0	210.1	-	-
Bananas				
With Bardheere	436.9	344.1	5 633	4 606
Without Bardheere (gross returns reduced by 20%)	316.9	242.7	4 337	3 516

Notes: (1) Sugar cane is dealt with separately in Chapter 6.

(2) Average of gu and der crops - only difference between the two is in the economic price of labour.

Source: Annex 1, and Appendix A.

4.4 Energy Prices

4.4.1 General

The prices assumed for diesel fuel and electricity will have a significant influence on the economic results. In the main economic anaylsis of the BDP, to be carried out in late 1987 or 1988, the benefit of Bardheere's hydro-electric output will presumably be valued on the basis of the costs of the alternative to hydro-electricity (HEP) which is thermal generation. To avoid double-counting of benefits, it will then be necessary to cost HEP consumption on irrigation schemes rather than to treat it as a free benefit made available by the dam.

This should be done using the same unit prices of HEP as are applied in the main BDP benefit analyses. At this stage, however, it is not known what unit prices will be assumed, so we have made our own assumptions, as described in Section 4.4.3.

4.4.2 Diesel Fuel Prices

In terms of 1985 constant prices, the basis on which the IBRD October 1986 Commodity Forecasts are presented, world oil prices averaged US$ 29/barrel between 1980 and 1985. In 1986 the sharpest fall in oil prices since the early 1930s then occurred, prices declining from US$ 26.7 in 1985 to under US$ 12 in early 1986. They have since recovered to about US$ 18/barrel in January 1987.

In their October 1986 forecasts IBRD predict a very slow and partial recovery in oil prices, to US$ 15 ($17.5 in 1987 constant price terms) in 1990 and US$ 23.5 (US$ 27.4 in 1987 constant price terms) in 1990 and US$ 23.5 (US$ 27.4 in 1987 constant prices) by the year 2000. This is some 19% below the 1980 to 1985 average. For analysis purposes the assumption made is that long term future oil prices would be the average of the IBRD year 2000 forecast (US$ 23.5) and the 1980 to 1985 average (US$ 29). The resultant figure of US$ 26.2/barrel at 1985 constant prices is 120% above the actual 1986 price. This percentage has been applied to calculate the projected price of diesel oil.

In late 1986 the diesel oil retail price at Jilib was SoSh 21.15/l. Total taxes and levies are SoSh 1.84/l, in which case the price excluding taxes would be SoSh 19.32/l. This has been taken as the present economic price before foreign exchange shadow pricing. Assuming an FE content of 80% in this price (this makes allowance for local refining) the present and projected economic prices per litre would be as follows:

	Present	Projected*
Economic	27.0	59.4 (say, 59)
Financial	21.2	46.6 (say, 47)

Note: * 120% above present price

4.4.3 Electricity Prices

In Table 4/6 of their 1984 report on Bardheere Dam Project Hydrology and Optimisation, Electroconsult calculated the total present value of 50% of the BDP's construction and recurrent costs over the project life to be US$ 166.7 million at a 10% discount rate; 92% of this sum was for capital costs and 8% for recurrent costs. If, on the basis of recent thinking, 75% rather than 50% of the BDP costs were considered to be chargeable to HEP generation, the cost would be US$ 250.0 million. Since world inflation has been low since 1984 and there are indications that the BDP may be less expensive to build than was previously thought, this might also be taken as the cost in 1987 prices.

Table 3.17 of the same report quotes an annual HEP output of 423 GWh (423 million kWh) of firm energy and 101 GWh of secondary energy from the proposed 105 MW HEP station. At a 10% discount rate the present value equivalent of the total output over a 50-year period would be 5 195 GWh. On this basis the cost per kWh generated would be:

$$\frac{\text{US\$ } 250\,000\,000}{5\,195\,000\,000} = 4.8 \text{ US cents}$$

The real cost per kWh consumed would, however, be substantialy higher because:

(a) there would be a gap of at least six years between the start of BDP capital expenditure and the start of HEP generation;

(b) consumption would build up over time and in the early years a substantial proportion of the generation capacity would be unutilised; and

(c) only part of the secondary energy would be utilised because, unlike firm energy, its output is by definition less reliable and part may often be surplus to electricity demand at the time that it is generated.

Taking account of all these factors, the real cost per kWh generated and consumed might well be somewhere between 6 and 10 US cents, at a 10% discount rate. At the official exchange rate of about SoSh 90/US$ 1 this would be equivalent to SoSh 5.4 to 9.0/KWh. In their 1986 Deshek Report AHT used a rate of SoSh 6/kWh. Since this is within the range given above, we have used SoSh 6/kWh for our project costing.

CHAPTER 5

FLOOD CONTROL BENEFITS

5.1 Introduction

Flooding is a fairly common occurrence in the Juba valley, as demonstrated by the fact that there have been three major floods in the past 10 years. The most seriously affected areas are in the stretch from Jilib district downstream to near the coast, where the river channel capacity is more or less the same as the mean annual flood (see Tables 2.7 and 2.8). Thus, on average, some overtopping of the river banks can be expected almost one year out of every two.

River flooding is confined to the Juba floodplain. At Bardheere the floodplain is only 500 to 700 m wide (AHT, 1985), widening to 1.0 to 1.5 km at Saakow, 4 km at the southern border of Bu'aale district, 8 km near the town of Jilib and 14 km at Kamsuuma and Jamaame, in the Lower Juba. Generally, the degree of flood damage increases downstream, because of the much larger areas of floodplain liable to inundation.

Flood damage is caused by rainfall as well as river floods. Much, if not most, of the damage caused by rainwater flooding, however, can be attributed indirectly to river flooding, because the high river levels, which very often coincide with periods of high rainfall, prevent the stormwater from draining off to the river through natural or artificial drainage channels. Elimination of excessively high river flows by Bardheere would thus greatly reduce stormwater flooding damage. Stormwater runoff is also inhibited by the numerous flood protection bunds which have been built to protect areas against river floodings. In many places these run across and thus block natural drainage channels. If river flooding were eliminated, as would be the case with Bardheere, these channels could be unblocked and stormwater damage would be considerably reduced.

In view of these points, the Bardheere flood control benefits have been valued on the basis of both the river and the stormwater flood damage being prevented.

Little detailed information is available on the damage caused by the 1977 flood, but estimates of the 1981 and 1985 flood damage do exist, in the form of reports by the Somali government and MMP-HTS (1981) and AHT (1985). To value future flood control benefits from Bardheere, our approach has been as follows:

(i) A broad assessment of the economic costs of flood damage has been made for the 1981 and 1985 floods. Since these costs form the basis of the projected future benefits, they are based on projected crop and input prices and crop yields rather than on the prices and yields prevailing in these two years.

(ii) These have than been related to the return periods for these two floods, to provide a basis for estimating the annual average value of flood damage and, thus, the annual flood control benefits of Bardheere dam. Based on the data presented in Sections 2.11.4 and 2.11.5 the 1981 flood is taken to be the 1-in-7 year flood and the 1985 flood to be the 1-in-4 year flood. Flood damage is taken to be negligible with the mean annual flood (MAF) but, because this is more or less equivalent to the river's bank-full capacity, floods significantly above the MAF level are assumed to cause some economic damage.

(iii) The 1981 and 1985 flood damage values calculated have been taken to represent the damage which would have occurred with the 1-in-7 year and 1-in-4 year floods at the present (1987) level of economic and social development in the area. As the population expands and the valley's economy grows, however, the cost of damage caused by a flood of a given return period will increase, because there will be a greater number of people and more economic activity and infrastructure liable to be affected. To take account of this, we have assumed that the flood control benefits (i.e. the value of flood damage prevented) will increase at a rate of 5% per annum from 1987 to 2010. For convenience of presentation and calculation, annual benefits have been taken to be uniform from then onwards, although in practice they would continue to increase.

5.2 The 1981 Flood

5.2.1 General

Serious flooding occurred in the Juba and Shebelle valleys in April/May 1981, causing widespread damage and dislocation. To assess the damage and make recommendations for immediate and longer-term measures required to alleviate flooding problems in the future, a two-part study was undertaken during and immediately after the flood. The specially created Somali Government Committee for Assessing the Damage caused by Flooding made an assessment district-by-district and published its report in July 1981. In conjunction with this, MMP and HTS were appointed by FAO to carry out a brief overall assessment. Their report (Flood Damage Assessment Study, MMP and HTS, September 1981) incorporated the committee's findings and published an English translation of the committee's full report as an annex. The MMP-HTS team spent two days overflying the Juba valley and a further week in the area. Despite the brevity of the study it provides much useful information.

5.2.2 The Extent of Flooding

A clear account of the behaviour and extent of the 1981 flood in the Middle and Lower Juba valley is given in the MMP-HTS report, an excerpt from which (pages 73 to 77) is reproduced below.

"Upper Juba

The road on the east side of the Juba valley north of Fanoole is a bush road which becomes impassable as a result of normal seasonal rainfall. In the 1981 gu it was affected only in as much as local diversions were in use much longer than usual. These diversions occurred at locations where the road crosses or skirts around riverine depressions which remained inundated in mid-July.

There are three bridges, located at Luuq, Bardheere and Bu'aale. These were not submerged by flood flow but some damage occurred to bridge abutment protection works at Luuq and Bu'aale which were temporarily repaired by mid-July. Access across the floodplains at the bridges at Bardheere and Bu'aale was interrupted while they were partially by-passed by floodplain flow.

Lower Juba

Downstream of Fanoole the flood water spread out, breaching the Fanoole road and supply canal earthworks to the east and entering the old river channel (Far Shebelle) to the west. North of Jilib, water escaped to the east towards Homboy through the gap in the partly-constructed Fanoole supply canal earthworks, inundating and damaging the road from Fanoole to Jilib. On the west bank the northern area of the Juba Sugar Project was protected by the river flood bund.

At Jilib the flood flow from both the floodplain north-east of Jilib and the river channel combined and became generally confined between the Juba Sugar Project and Jilib State Farm's flood bunds. This concentration of flow coupled with incompleted bunds on both banks required emergency protection work which prevented breaching.

Water flowing along the Far Shebelle filled the depression at the downstream end (Scorpion lake) and then flowed for some 17 days through the main cane areas of the sugar project, resulting in breaches of the main road, canal and drain earthworks and finally passing through man-made breaches in the southern flood bund. From this location the Far Shebelle floodwater combined with spillage from the river channel and flowed down the western floodplain. This cut the main road (marine plain road) to the Juba Sugar Project for the second time, before passing through the future Mogambo project area behind the banana plantations. It then crossed the main Kismayo road before flowing into the large depression, Deshek Waamo, north-west of Kismayo.

The marine plain road was inundated at two locations over a total length of some 4 km and individual breaches occurred at both locations. This road was still closed in mid-July, having first been cut off on the 18th May. It may be noted that this road was built as an emergency measure following the 1977 flooding and, consequently, permanent flood protection to the road was not considered. The need for protection would be avoided by construction of a river crossing in the vicinity of the project. Elsewhere, minor damage occurred at points of overflow on the Kismayo road near Far Janno and Bur Koy as a result of scour and loss of road shoulder material.

Between Jilib and Kamsuuma, spillage from the river channel to the east led cross-country flow towards the Kamsuuma-Jilib road. When the road embankment breached this allowed water to flow through into the storage area at the tail end of the Shebelle swamps before draining back to the river channel downstream of Mombassa island during the flood recession. Approximately 2 km of the Kamsuuma-Jilib road was damaged and temporary repairs had been completed by mid-July. Downstream of Jamaame, flow to the south from a major breach in the river flood bund crossed the road from Ararra bridge to Jamaame and minor scour damage occurred with some loss of road shoulder material."

Table 5.1 shows the estimates of flood areas made by the Committee and MMP-HTS.

TABLE 5.1

Estimates of Areas Flooded in 1981 (ha)

River reach	Gross area (MMP-HTS)	Crop area flooded MMP-HTS	Committee
Bardheere to Fanoole	40 600	16 250	15 500
Fanoole to the coast	96 000	35 000	48 652

Source: Table 11.3, Flood Damage Assessment Study report, MMP-HTS 1981.

The MMP-HTS estimates are based on aerial survey whereas the committee estimates were made by means of field visits and information from local authorities and other sources. Considering the short duration of the surveys and the difficulties of obtaining precise figures, the differences between the two estimates of crop land flooded are not very great.

Clearly, the 1981 flood affected a very large area of the Juba valley below Bardheere, with just under 1 400 km^2 being inundated. Within this area some 51 000 to 64 000 ha of crop land was flooded. Apart from the crop losses, the flooding caused substantial infrastructural damage and serious disruption to the local population and economy. According to the committee's report, the number of families who were evacuated from the villages or were cut off for significant periods was over 12 000, as shown in Table 5.2. With an average family size of 5.5 (the size assumed for Homboy project planning) the total population affected was thus 66 000.

TABLE 5.2

Villages Evacuated or Cut Off in the 1981 Flood

District	Villages evacuated: Number	Villages evacuated: Number of families	Villages cut off: Number	Villages cut off: Number of families
Bardheere	-	-	-	-
Saakow	3	45	24	1 705
Bu'aale	-	-	11	701
Jilib	24	3 204	33	3 146
Jamaame	6	400	16	2 651
Kismayo	7	347 (1 735 persons)	-	-
Total	40	3 996	84	8 203

Source: Information from the Somali National Flood Committee, presented in Annex 1 of the Flood Damage Assessment Study, MMP-HTS (1981).

Details of the length of time for which the villages were evacuated or cut off were not given. Nevertheless, the flooding clearly caused severe distress and inconvenience to many local people.

5.2.3 Damage to Rainfed and Deshek Crops

Taking the average of the two estimates in Table 5.1, 15 875 ha of gu crops were flooded in the area between Bardheere and Fanoole. The committee classified this as all maize, although in Bardheere, Saakow and Bu'aale districts sorghum is also quite important. Since the returns per hectare from maize and sorghum are fairly similar, the benefit valuation has been based on maize. Virtually all the crops were destroyed by the flooding. Many farmers then replanted, from June onwards, but according to the MMP-HTS report, the condition of the crops did not look good. Increased pest damage due to this out-of-season planting was severe in some places. Another problem is that the late planting may have prevented the planting of a der crop in September/October.

Based on Table 5.1, the crop area flooded between Fanoole and the coast has been taken to be 41 800 ha, also mainly maize. Again, crop damage was severe. Many farmers replanted but pest damage, especially from maize stalk borer, appeared to be substantial.

In its assessment of damage costs the committee seems to have assumed that all the flooded crops were lost. With a total crop area of 57 675 ha and an assumed yield of, say, 0.5 t/ha (this is lower than Homboy because the rainfall over the area as a whole is normally less than at Homboy) the total output lost would be 28 837 t of maize. At economic prices (Table 4.1) this would be worth SoSh 842 million at High Prices and SoSh 715 million at Low Prices ($6 027 000 and $5 075 000 in direct foreign exchange (FE) benefits). Some deduction from this should, however, be made to take account of the value of the replanted crops, although their yields and returns would have been fairly low. A deduction of one-quarter has therefore been made, the total rainfed and deshek net crop losses then being:

	High prices	Low prices
At economic prices	SoSh 631 million	SoSh 536 million
Direct FE value	$4.52 million	$3.81 million

5.2.4 Damage at Juba Sugar Project

JSP suffered severe flooding and, at its peak, some 1 800 ha of cane land was under water (JSP Report on Flooding May to June 1981 and Financial Review of Project, BA1 June 1981). Considerable infrastructure damage also occurred. JSP costs due to the flooding were reported to be as follows, excluding lost cane production and cane replanting costs:

Item	SoSh million
Emergency repairs during flooding	1.40
WDA contract works	4.64
JSP Agricultural Department works	3.66
Repairs to the Marine Plain road	5.90
Short-term relief work	1.50
Total	17.10

Source: BAI report on JSP May to June 1981, flooding, Main Report, Section 2.6.

Based on the exchange rate of about SoSh 6.35/US$ 1 prevailing at the end of 1981, the cost in US dollar terms would have been US$ 2.69 million or SoSh 242 million at present exchange rates. This may, however, overstate the costs somewhat, because exchange rates in the early 1980s were unrealistically high.

An alternative method of upvaluing the costs to 1987 levels is to apply the inflation factor derived from the Mogadishu cost of living index, the only inflation index available for Somalia. The base year for this index is 1977 (i.e. 1977 = 100) and in June 1981 the index was 319. By November 1986 it had reached 1 914 but had been up to 2 047 earlier in the year. The rate of inflation between November 1985 and November 1986 was 30.4%. To derive an inflation factor for updating costs to early 1987 (say, March) levels, this inflation rate has been assumed to continue, the index for March 1987 thus being 10% higher than in November 1986 at 2 105. On this basis the SoSh 17.1 million of JSP 1981 flood damage costs would be equivalent to SoSh 112.8 million at early 1987 prices (i.e. 6.6 times higher). With an FE content of say, 50% (US$ 627 000), the economic cost would then be SoSh 141 million.

Some 607 ha of sugar cane was seriously affected by the flooding, of which 238 ha was estimated to be permanently lost through inundation. A small part of this has subsequently been reclaimed, but it has been assumed that the net loss was at least 200 ha. According to the 1981 BA1 report, all the remaining 369 ha needed replanting. The loss of cane output was therefore substantial.

The cost of the lost 200 ha can be valued in two ways, in terms of either the loss of output from 200 ha in perpetuity or the capital costs of developing another 200 ha to replace it. The former may overstate the costs, because it would be reasonable to assume that JSP would do its best to maintain the scheme's total production by developing new land or by reclaiming the 200 ha by improved flood protection and pumped drainage. Since most of the flooded area has not in fact been reclaimed the assumption made is that JSP has developed another 200 ha elsewhere. On the basis of the estimates made for JSP Phase II the capital costs of developing this land have been taken to be as follows:

	Cost/ha (US$)	Total cost (US$'000)	FE content (%)	FE cost (US$'000)
Bush clearance, level survey and land planing	1 400	280	70	196
Canal and drain earthworks and roads	1 400	280	70	196
Canal and drain structures	750	150	70	105
Sprinkler irrigation system	6 000*	1 200	80	960
Total		1 910		1 457

Note: * Assuming that the US$ 2 410/ha worth of sprinkler equipment and pumpsets was recovered from the flooded area and could be re-used on the new land.

Total costs would thus be US$ 1 910 000 or SoSh 171.9 million, and the FE cost would be US$ 1 457 000. With FE shadow pricing, the economic cost would be SoSh 237.5 million. There would be no increase in JSP recurrent costs, the annual expenditure on the new 200 ha being the same as on the 200 ha which it replaced.

For analysis purposes damage on the 369 ha of land which needed replanting has been calculated on the basis of the loss of one year's production - the resultant value is considered to represent the additional replanting costs as well as the output losses. Cane and sugar yields and rendements would be as for the future 'without Bardheere' situation, the cane yield being 80 t/ha and the rendement being 9.5%, giving a sugar yield of 7.6 t/ha per annum. Total sugar output lost would thus have been 2 804 t. Based on the figures given in Section 6.1.2, the net value of this lost production would have been:

		Economic prices (SoSh)	Direct FE (US$)
1.	Sugar output lost:		
	Value per tonne	58 200	406
	Total value	163.2 M	1 138 420
2.	Variable costs saved:		
	Per tonne	11 610	61
	Total	32.6 M	171 040
3.	Net value	130.6 M	967 380

5.2.5 Damage to Banana Farms

The Flood Committee estimated that 273 ha of bananas were damaged by the 1981 flood, but no details were given. In some places damage was minimised by the farmers pumping out the flood water before the plants were seriously affected, whereas in other places the crop was completely lost and replanting was necessary. In view of the vulnerability of bananas to waterlogging the total damage would have been very substantial.

Future net returns per hectare from bananas without Bardheere are estimated to be as follows (Table 4.2):

	Per hectare
High prices:	
- Economic returns	SoSh 316 900
- Direct FE returns	US$ 4 337
Low prices	
- Economic returns	SoSh 242 700
- Direct FE returns	US$ 3 516

In the absence of detailed information on the actual flood damage to bananas the assumption made is that the total cost, including loss of production, replanting costs and damage to farm infrastructure and facilities, would be equivalent to the net returns from one year's production on the 273 ha flooded. Total damage costs would thus be:

	High prices (SoSh)	Low prices (SoSh)
Economic costs	SoSh 86.5 M	SoSh 66.3 M
Direct FE cost	US$1 184 000	US$959 870

5.2.6 Damage to Infrastructure and Facilities

In comparison with the agricultural losses, the damage to infrastructure and facilities was generally slight, apart from at JSP. The Fanoole canal was breached and some 2½ km of the Jilib to Kamsuuma metalled road was damaged, but temporary repairs were made rapidly and the road was not closed for long. Damage to housing was, however, substantial.

Data from the 1981 MMP-HTS report, Annex I, which is a translation of the Committee's report, presents detailed estimates of the costs of the damage, repairs and flood relief operations undertaken in the five districts of the Middle and Lower Juba (Saakow, Bu'aale, Jilib, Jamaame and Kismayo). Excluding agricultural losses and the repair costs of the JSP Marine Plain road, which are taken into account separately in Sections 5.2.3 and 5.2.4, the total cost was SoSh 18.8 million. This is equivalent to SoSh 124.1 million at early 1987 prices. Since the direct FE cost of most of the expenditure incurred would be relatively low, the FE content has been taken to be 20% (US$ 276 000); the economic cost with FE shadow pricing would thus be SoSh 136.5 million.

5.2.7 Social and Economic Disruption

The social and economic disruption and distress caused by the 1981 flood would have been very substantial, with some 22 000 people being evacuated from their villages and a further 45 000 people being cut off for significant periods (see Table 5.2).

In view of its magnitude, it would be useful if the social and economic costs of this disruption could somehow be taken into account in the estimation of Bardheere flood control benefits, even though the estimates made would be unavoidably arbitrary in nature. One approach could be to base the economic costs of the disruption on the total number of people evacuated and the opportunity cost of labour, on the assumption that the latter gives at least some impression of the value of people's time, in social and economic terms, in their place of abode.

For calculation purposes the average family of 5.5 persons could be taken to be three adult equivalents. At the weighted average economic price of labour, SoSh 110 per labour-day, the value of these people's time spent in their abode would then be SoSh 300 per family per day, the total value for the 3 996 families evacuated being SoSh 1.20 million. With an average period, of, say, two weeks away from their village before their return, the total cost would be SoSh 17.8 million.

In monetary terms this is insignificant compared with the other costs of the 1981 flood. In view of the poor basis for the estimate and the relatively low cost, the economic and social disruption has not been included in the analysis in quantitative terms. The approach adopted has instead been to treat the avoidance of such disruption as an unquantifiable, though important, flood control benefit of the dam.

Disruption to road transport and communications could be a serious problem with large floods which cause road closure through inundation or physical damage. In 1981, however, the most important road, that running from Kismayo to Jilib and then on to Mogadishu, was apparently not cut for any substantial period. Costs of transport and communications disruptions have therefore not been quantified for the analysis.

5.2.8 Total Economic Damage Resulting from the 1981 Flood

Based on the above estimates, the total economic costs of the damage caused by a flood of the magnitude of that which occurred in the Middle and Lower Juba valley in 1981 (the 1-in-7 year flood) are estimated to be SoSh 1 350 million and SoSh 1 235 million at High and Low prices respectively (see Table 5.3). The values in terms of direct FE costs are US$ 9.03 million and US$ 8.10 million. These are in terms of 1987 prices and the current state of development of the valley, but with projected economic prices and crop input and output levels.

TABLE 5.3

Economic Costs of a Flood of the Magnitude of the 1981 Flood (at 1987 Constant Prices)

	High prices		Low prices	
	Economic costs (SoSh million)	FE costs (US$'000)	Economic costs (SoSh million)	FE costs (US$'000)
Loss of rainfed and deshek crop output	631	4 520	536	3 810
Juba Sugar Project:				
- Damage, repairs, etc.	141	627	141	627
- Replacement of 200 ha of irrigated land abandoned due to flooding	237	1 457	237	1 457
- Loss of sugar output on 369 ha	131	967	131	967
Sub-total	509	3 151	509	3 051
Damage on banana farms	86	1 184	66	960
Damage to infrastructure and facilities	124	276	124	276
Total	1 350	9 031	1 235	8 097

Total economic costs of the damage resulting from the 1-in-7 year flood are thus very substantial. At High Prices, 47% of the 1981 flooding costs were due to losses of rainfed and deshek crop output, 38% were attributable to the flooding of JSP, 9% to damage to other infrastructure and facilities and 6% to lost banana production.

The breakdown in costs between the different items will differ from flood to flood, according to its particular characteristics and impact in different parts of the valley. For example, the future effect of a 1-in-7 year flood on JSP will be less than in 1981, because additional flood protection has since been installed by the project. A larger flood, however, capable of breaking through the protective bunds and submerging the whole area (as virtually happened in 1977) would result in economic losses which in total would far outweigh those in the rest of the valley. The important factor in the valuation presented in Table 5.3 is the total, not the values for each component.

5.3 The 1985 Flood

5.3.1 General

A detailed assessment of the damage caused by the 1985 gu flood was made by AHT in October of that year. The survey was based on field visits and interviews with Government officials, village chiefs, farmers and others. Unfortunately, the proposed aerial survey was not carried out, for technical reasons.

In the 1985 flood, river discharges were lower than in 1981 but the gu rainfall was far above average, as in 1981. The area flooded was considerably less than in 1981. AHT's main conclusions regarding flood damage can be summarised as follows:

(a) The total cost of the gu 1985 flood damage was about US$ 3.11 million, of which US$ 2.94 million was agricultural and US$ 0.17 million was for infrastructure and settlements.

Much of the damage was due to rainwater flooding. The above figure does not take account of transport delays, delays in Mogambo project construction, the draining of floodwater by pumping, social disruption and other adverse consequences.

(b) Two-thirds of the agricultural damage occurred in Jamaame/Kismayo and over 20% in the Homboy desheks, the latter being caused by rainfall rather than river flooding. Damage elsewhere in Jilib district was 4% of the total; that in Bu'aale (6%) and Saakow (2%) was comparatively small, whilst in Bardheere district there was no significant flooding.

(c) In economic terms the most serious effect of the flooding was the damage to the banana plantations; this accounted for over one-third of the total agricultural losses. Some 554 ha of planted bananas were flooded.

We have recalculated the AHT estimates on the basis of the prices and input and output levels adopted for this study, the assumptions made being outlined in Sections 5.3.2 to 5.3.4.

5.3.2 Damage to Rainfed and Deshek Crops

A total of 11 571 ha of crop land was flooded, most being under maize. AHT estimated that two-thirds of this crop area was destroyed and the remaining one-third suffered a serious reduction in yields; 38% was estimated to have been replanted.

Our valuation of these losses has been based on the assumptions and parameters applied for the 1981 flood, maize being taken as the representative crop, with a yield of 0.5 t/ha, and the net crop area lost being three-quarters of the total flooded. On this basis the total output lost would be 4 339 t of maize, valued as follows:

	High prices	Low prices
At economic prices	SoSh 126.7 million	SoSh 107.6 million
Direct FE value	US$ 906 900	US$ 763 700

5.3.3 Damage to Banana Farms

Damage of banana farms was more serious than in 1981, due particularly to stormwater flooding. High flows in the river Juba and blockage of many natural drainage lines by flood bunds hindered the drainage of the affected areas. According to AHT, of the 554 ha of bananas flooded, 314 ha were destroyed and yields were reduced by 30% to 40% on the other 240 ha.

Our valuation has been based on the complete loss of one year's gross output on the 314 ha destroyed and a reduction in gross output of 35% on the other 240 ha. As shown in Table 5.4, losses would be high, at SoSh 239 million and SoSh 202 million at High and Low Prices, respectively.

TABLE 5.4

Projected Production Losses on Banana Farms with a Flood of the Same Magnitude as in 1985 (at 1987 Constant Prices)

	High prices		Low prices	
	Economic prices	Direct FE (US$)	Economic prices	Direct FE (US$)
Gross output per ha of bananas, without Bardheere (see Tables 3.8 and 4.2) (SoSh)	599 900	6 478	507 000	5 451
Value of Flood Damage				
Loss of output on 314 ha destroyed (SoSh million)	188.4	2.03	159.2	1.71
35% loss of output on 240 ha	50.4	0.54	42.6	0.46
Total	238.8	2.57	201.8	2.17

5.3.4 Other Costs

AHT estimates of infrastructure damage costs were as follows:

		US$
-	repairs to three roads	42 000
-	repair and rebuilding of houses	131 500
	Total	173 500

There were also substantial other costs resulting fom the 1985 flood, including:

- crash programme to refill breaches and to raise bunds;
- transport delays;
- drainage by pumping;
- delays to construction works in large projects, mainly Mogambo;
- delays in establishing new banana and sugar cane crops;
- damage to river embankments.

It was not possible to quantify these costs, but AHT estimated them to total somewhere between US$ 1 and US$ 3 million. We have therefore assumed an overall figure of US$ 2 million for these items and the road and house repair costs listed above. With a direct FE content of, say, 40%, the direct FE cost would be US$ 0.80 million and the economic cost would be SoSh 216 million.

5.3.5 Total Economic Damage Resulting from the 1985 Flood

Based on the estimates in Sections 5.3.2 to 5.3.4, the total economic costs of the damage caused by a flood of the magnitude of that which occurred in 1985 (the 1-in-4 year flood) would be SoSh 582 million and SoSh 526 million at High and Low Prices, respectively (see Table 5.5). The values in terms of direct FE costs are US$ 4.28 million and US$ 3.73 million. These are 41% to 47% below the costs for the 1-in-7 year flood (1981). The composition of the costs is different, because in 1981 JSP suffered severely whereas the flooding of banana farms was much less than in 1985. In the latter flood there was little serious damage at JSP. As emphasised in Section 5.2.6, the important factor is the total value of the damage, not its breakdown by components, in any particular year.

TABLE 5.5

Economic Costs of a Flood of the Magnitude of the 1985 Flood (at 1987 Constant Prices)

	High prices		Low prices	
	Economic costs (SoSh million)	FE costs (US$'000)	Economic costs (SoSh million)	FE costs (US$'000)
Loss of rainfed and deshek crop output	127	907	108	764
Loss of banana output	239	2 570	202	2 170
Other damage	216	800	216	800
Total	582	4 277	526	3 734

5.4 Average Annual Flood Control Benefits

In terms of the present (1987) state of development of the Juba valley the Bardheere flood control benefits for floods with a 1-in-4 and 1-in-7 year return periods are as follows (see Tables 5.3 and 5.5):

Return period	High prices		Low prices	
	Economic benefit (SoSh million)	Direct FE benefits (US$'000)	Economic benefits (SoSh million)	Direct FE benefits (US$'000)
1 in 4 years	582	4 277	526	3 734
1 in 7 years	1 350	9 031	1 235	8 097

These have been plotted on to a Gumbel Distribution graph (Figure 5.1) in order to derive the flood control benefits from floods at different return periods, and thence the average annual benefits. This has been done in terms of economic benefits at High Prices. As Figure 5.1 shows, combining the 1-in-4 year and 1-in-7 year return periods benefits produces a logical curve, with floods with a return period of below about 2.75 years (63% probability of non-occurrence) causing no significant damage; that is, there are no flood control benefits with floods of a return period of 2.75 years or less, which is not much above the mean annual flood (2.3 years).

In 63% of years, therefore, there would be no significant flood control benefits from Bardheere. In the remaining 37% of years the benefit would range from some SoSh 150 million in the 1-in-3 year flood to SoSh 4 750 million in the 1-in-100 year flood. Reading off the curve, the total benefit over a 100-year period (i.e. covering probabilities of non-occurrence from 1% up to 99%) would be about SoSh 47 400 million, or an average of SoSh 474 million per year. This is 35.1% of the 1-in-7 year value (SoSh 1 350 million) shown above. Applying this factor of 0.351 to the other 1-in-7 year values, annual average flood control benefits would be as follows:

High prices:

- Economic benefits — SoSh 474 million
- Direct FE benefits — US$ 3 171 000

Low prices:

- Economic benefits — SoSh 434 million
- Direct FE benefits — US$ 2 843 000

These are in terms of the current state of development. Table 5.6 shows the year-by-year values from 1995 onwards, after allowing for the assumed 5% per year (compound) increase in benefits due to the progressive increase in population and economic activity in the flood-prone areas of the valley.

TABLE 5.6

Bardheere Flood Control Benefits (at 1987 Prices)

Year	High prices		Low prices	
	Economic benefits (SoSh million)	FE benefits (US$'000)	Economic benefits (SoSh million)	FE benefits (US$'000)
(1987)	(474)	(3 171)	(434)	(2 843)
1995	700	4 684	641	4 199
1996	735	4 918	673	4 409
1997	772	5 164	707	4 629
1998	810	5 422	742	4 861
1999	851	5 693	779	5 104
2000	893	5 978	818	5 359
2001	938	6 277	859	5 627
2002	985	6 591	902	5 908
2003	1 034	6 920	947	6 204
2004	1 086	7 266	994	6 514
2005	1 140	7 630	1 044	6 840
2006	1 197	8 011	1 096	7 182
2007	1 257	8 412	1 151	7 541
2008	1 320	8 832	1 209	7 918
2009	1 386	9 274	1 269	8 314
2010 to 2034	1 455	9 738	1 333	8 729
Present value at 1994 (Year 0) at:				
- 5% discount rate	19 863	132 931	18 194	119 164
- 10% discount rate	10 194	68 217	9 336	61 153
- 15% discount rate	6 367	42 608	5 831	38 196

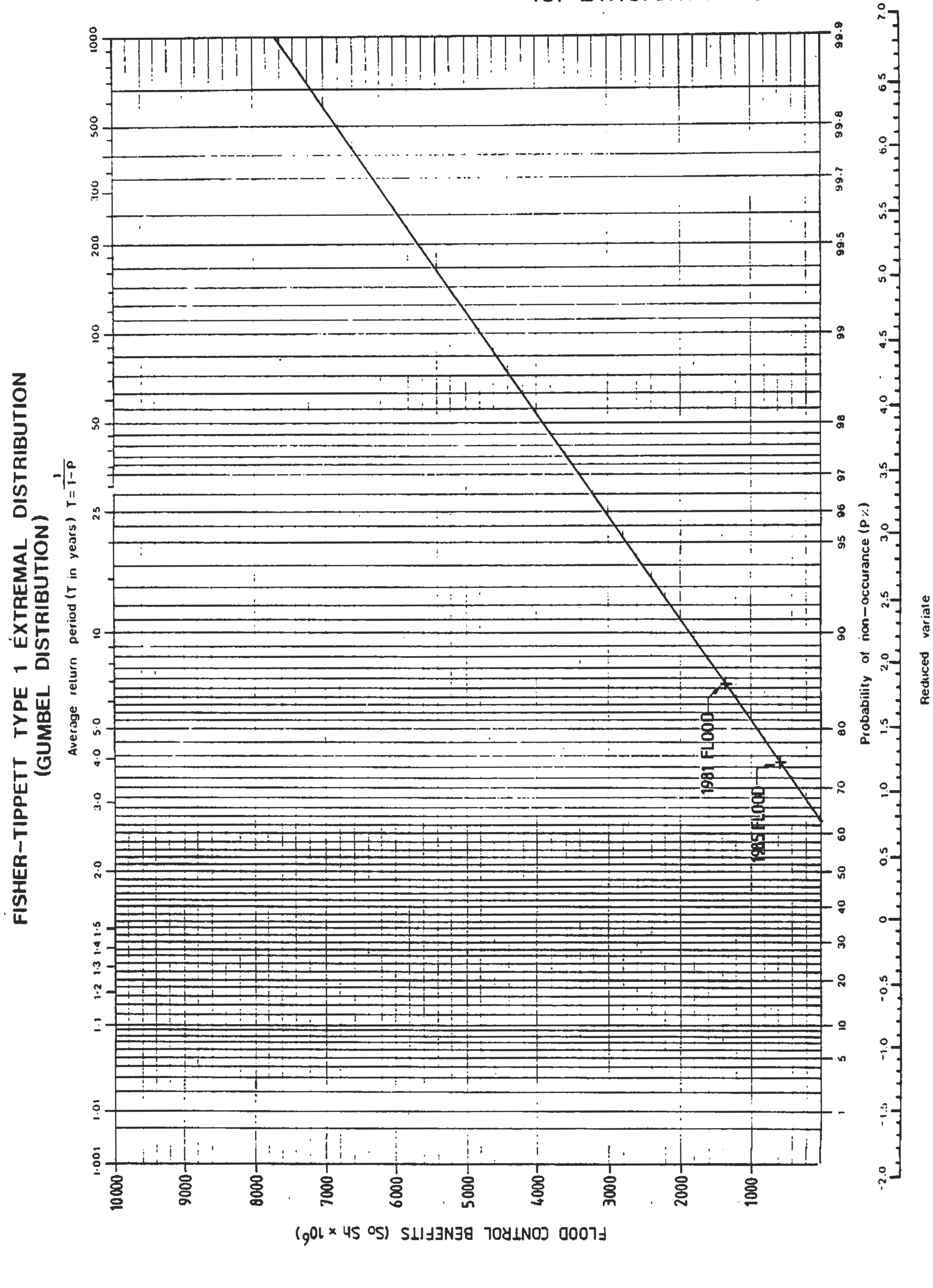
It might be argued that the curve in Figure 5.1 exaggerates the likely flood damage in years with a probability of non-occurrence of over 90% (i.e. floods with a return period of over 10 years). This is because no detailed data on damage exists for such floods, and the total value of rainfed and irrigated crops, irrigation facilities and other infrastructure in the valley liable to flooding is not as high as the values towards the top of the curve, which are in the SoSh 2 000 to SoSh 7 000 million range.

This argument is not considered to be valid however, because the total value of crops and facilities at risk certainly exceeds this range and none of the three major irrigation schemes has flood bunds which can withstand floods above the 20 to 30 year return period. If, for example, the JSP flood bund were overtopped and the whole scheme were flooded, with the loss of one year's cane crop production, say, 54 700 tonnes of sugar (see Section 6.1.2), the loss of gross output would be SoSh 3 183 million at economic prices. Such a flood would also probably destroy much of the scheme, the total capital cost of which at present day prices would be at least US$ 300 million. At the official exchange rate this is equivalent to SoSh 27 000 million or, say, SoSh 37 000 million with foreign exchange shadow pricing. Rehabilitation of the scheme after severe flood damage might easily cost SoSh 5 000 to 10 000 million at economic prices, if the damage were really extensive. Thus the cost of flood damage on JSP alone might well exceed the values shown in Figure 5.1.

Total flood control benefits from Bardheere would be very large, their total present value at High Prices in 1994 terms being SoSh 10 194 million (US$ 68.22 million in direct FE) at a 10% discount rate. This high value is by no means surprising. The Lower and Middle Juba Valley is very prone to flooding, due to the river's hydrological characteristics and the physiography of the floodplain, and the 1981 and 1985 floods have demonstrated the substantial damage that even quite moderate floods (i.e. those with a return period of only 1-in-4 to 1 in 7 years) can cause. Elimination of flooding by building Bardheere dam will therefore produce correspondingly high economic benefits, sufficient to meet a considerable proportion of the dam's cost. Moreover, the social benefits from flood control would be considerable, because of the large population living in the flood-prone areas.

Figure 5.1

Flood Control Benefits for Different Return Periods



CHAPTER 6

BENEFITS FROM EXISTING IRRIGATION SCHEMES

6.1 Juba Sugar Project Phase I

6.1.1 General

Bardheere would have three main effects on JSP I, as follows:

- by raising jilaal river flows it would ensure that adequate water is available for pumping throughout the year;

- by providing a reliable supply of energy, in the form of HEP from the dam, it would enable the project to meet its full irrigation requirement throughout the year. Available diesel supplies could then be concentrated in other uses such as agricultural operations and transport;

- it would remove the risk of river flooding, although this risk has already been greatly reduced by the flood protection works undertaken. Bardheere flood protection benefits have been estimated separately from the other JSP I benefits, in Chapter 5; the cane yield and area estimates presented below thus exclude any losses caused by river flooding.

As described in Section 2.6.3, taking one month as the average period without significant irrigation in the jilaal, the cane yield loss due to low jilaal flows would be 9 t/ha and the sugar loss would be 900 kg/ha. Removal of the pumping energy constraint due to BDP would, however, have a larger impact on production than the provision of adequate jilaal flows, because it would enable the number of irrigations to be increased by at least six, and probably more. Energy costs would be greatly reduced and maintenance and replacement costs would also go down, because electric motors are cheaper to buy and maintain than diesel engines.

JSP I is an enormous consumer of diesel fuel, mainly for the overhead sprinkler irrigation system. JSP's 1987 budget envisages a total consumption of 5.5 million litres for irrigation pumping. By enabling JSP to replace diesel pumping with electric pumping Bardheere would bring it very substantial benefits. If diesel fuel availability is still a constraint in 1995, which is certainly possible, irrigation pumping and other energy-using operations would still be at sub-optimal levels and the estate's output would remain well below its potential.

The JSP I economic benefits from Bardheere have been discussed in terms of the increase in net returns from cane and sugar production (Section 6.1.2), the savings in pumpset operation, maintenance and depreciation due to the changeover from diesel pumping to electricity (Section 6.1.3) and the savings in energy costs (Section 6.1.4).

6.1.2 Production Benefits

To calculate JSP I production benefits from Bardheere, projections have been made of the future situation with and without the dam. The magnitude of these benefits depends heavily on the assumptions made regarding the future availability of other key inputs as well as fuel, such as spare parts, fertilisers and agro-chemicals. Given the uncertainties involved we have taken Booker Agriculture International's (BAI) forecasts A and B from their 1985 medium term development report as representative of the 'without Bardheere' and 'with Bardheere' situations, respectively. The main difference between the two is the reduced number of irrigations in the former, which is attributed to limited diesel fuel supplies; the total cane area harvested per annum (7 180 ha) was taken to be the same in both cases and rates of use of other inputs per hectare were similar.

(a) Production With and Without Bardheere

With only the 12 irrigations assumed in Forecast A, cane yields would be 80 t/ha harvested, well above the 1983 to 1986 average. BAI assumed an average rendement of 9.17% but based on subsequent JSP experience in 1985 and 1986 (see Table 2.3), this seems slightly low - a figure of 9.5% has therefore been applied, giving a sugar yield of 7.6 t/ha. Total JSP I cane and sugar output per year would then be 575 748 t and 54 696 t respectively. With the total cane area of 7 365 ha (185 ha is needed to grow cane planting material) the cane and sugar yields would be 78.2 t and 7.43 t per hectare of total cane.

With the removal of both the pumping energy and jilaal low flows constraints Bardheere can be expected to produce some improvement in rendements as well as major cane yield increases. In Forecast B, BAI assumed an improvement of 0.26% in rendement. This has been rounded to 0.25% to give a rendement with Bardheere of 9.75%. Taking the BAI Forecast B cane yield of 105 t/ha as the long-term average after 1995, yields and total outputs with Bardheere would be as shown in Table 6.1.

TABLE 6.1

JSP I - Cane and Sugar Output with Bardheere

	Cane	Sugar
Yield per hectare harvested	105 t	10.24 t
Area harvested	7 180 ha	-
Total output per year	753 900 t	73 523 t
Total cane hectares	7 365 ha	-
Yield per cane hectare	102.4 t	9.98 t

Total sugar output is slightly above the theoretical factory capacity of 70 000 t per year, but the increase is only 5%, which could almost certainly be accommodated.

Based on these figures, Bardheere would result in an increase in JSP's annual production of 178 152 t of cane and 18 827 t of sugar. Since this will require very little, if any, additional capital investment and no additional cane planting, the increase could be obtained very rapidly after the dam comes into operation in 1995. The practicability of achieving rapid rises in cane and sugar output is demonstrated by the increases of 136 584 t and 12 144 t, respectively, obtained between 1984 and 1985 (see Table 2.3). For analysis purposes it is assumed that in terms of total net returns 50% of the increase is achieved in 1995 and the full 100% from 1996 onwards.

(b) Economic Value of the Increased JSP I Gross Output Due to Bardheere

Derivation of an economic price for the sugar produced is based on BAI price estimates made in 1985 and IBRD data and projections, prices being calculated in terms of long-term projected prices at 1987 constant values. Since the 1980 to 1985 recorded world market prices and the IBRD long-term projected prices are virtually the same, only one price, an average of the two scenarios, has been used. Table 6.2 shows the price calculation, which also takes account of the value of molasses produced.

Based on the prices derived above, the economic value of the extra 18 827 t of sugar produced by JSP I as a result of Bardheere would be as follows:

	Value per year
With FE shadow pricing	SoSh 1 096 million
Direct FE benefits	US$ 7.64 million

(c) Increase in JSP I Non-irrigation Operating Costs Due to Bardheere

Apart from irrigation pumping, which is dealt with separately in Section 6.1.4, the expansion in JSP I's output due to Bardheere would involve direct increases in irrigation labour, cane harvesting, cane transport and factory processing costs.

According to the JSP Agricultural Department's draft parameters for the 1987 budget, labour and machinery requirements for the various field operations involved are as follows:

- Sprinkler irrigation: 2 man days/ha per irrigation
- Cane harvesting: 61 man days/ha; based on the projected 1987 yield, say 0.8 day/tonne
- Cane loading with Cameco loader: 16 t/hour
- Cane transport with Ford 6610 (80 hp) tractor and two trailers: 5.5 t/hour

Assuming eight extra irrigations compared with the 'without Bardheere' situation, the additional irrigation labour requirements would be 16 man days/ha, the total for the estate then being 117 840 (7 365 ha x 16). At 0.8 days/t, 142 522 man days would be needed to harvest the 178 152 t of additional cane. Total additional labour use would then be 260 362 man days. The SoSh 110/day economic price used elsewhere in the study has therefore been applied for irrigation and also general labour.

Cane cutting is an arduous task for which a premium wage of SoSh 120/day, SoSh 50 above the general JSP labour rate, is paid. A rate of SoSh 160/day (SoSh 110 plus 50) has thus been taken as the economic cost of cane cutting labour.

TABLE 6.2

Derivation of the Economic Price of JSP Sugar (at 1987 Constant Prices)

		US$/tonne
Projected world market price of raw sugar:		
At 1985 constant prices(1)		254
- Adjusted to 1987 prices (+ 16.5%)(2)		296
10% quality premium for mill-white sugar (the type produced by JSP)(3)		30
Bagging(4)		17
Freight, insurance, etc.		60
CIF Mogadishu		403
Equivalent value in SoSh:		
- At official exchange rate		36 270
- At shadow exchange rate		54 405
Harbour fees (3% of CIF cost at official exchange rate)		1 088
Port handling and transport		2 720
Finance, documentation, administration, etc. (5% of CIF cost)		1 813
Cost at Mogadishu warehouse		41 891
Transport from JSP to Mogadishu warehouse: 450 km at SoSh 5 per tonne - km		2 250
Value at JSP		39 641
Addition for value of molasses exports, at US$ 3/tonne of sugar (molasses output = 5% of sugar output and export price is US$ 60/t)		270
Total value without FE (foreign exchange):	shadow pricing	39 911
	say,	39 900
Direct FE benefits:	sugar	36 270
	molasses	270
Total		36 540
say,		36 500
		(US$ 406)
Economic price with FE shadow pricing of 1.5 times the official exchange rate		58 181
say,		58 200

Notes:
(1) Based on World Bank price projections of October 1986 for raw sugar FOB and stored at Greater Caribbean port.
(2) based on IBRD manufacturing unit value (MUV) Index, July, 1986.
(3) Weight loss of 6.5% plus additional processing costs compared with raw sugar (Source: BAI 1985).
(4) BAI 1985, figure adjusted to 1987 values.

Source: BAI 1985 and Consultant's estimates.

Extra machine use would be as follows:

- cane loaders: 178 152 t divided by 16 = 11 134 hours
- cane transport: 178 152 t divided by 5.5 = 32 391 hours.

Cane transport costs have been based on the hourly economic costs of tractor plus trailers used for bananas, SoSh 2 050/hour (direct FE cost of US$ 16.2/hour). Data from the JSP 1987 budget indicates that the hourly costs of cane loaders are roughly similar to those of cane haulage.

Information provided by BAI indicates that the costs of JSP sugar processing (i.e. factory costs) since 1982 have been as shown in Table 6.3.

TABLE 6.3

JSP Sugar Factory Costs (US$/tonne of sugar)(1)

Item	1982	1983	1984	1985	1987 budget
Sugar output (tonnes)	22 213	28 113	26 954	39 103	42 615
Costs (rounded):					
Staff and labour	28	31	10	11	12
Operating materials	27	25	6	9	26
Maintenance	34	26	5	7	36
Machine hire	6	8	3	13	18
Other costs	16	15	4	8	3
Depreciation	51	36	7	4	3
Total	171	165	35	47	86

Notes: (1) 1986 figures not yet available.

Source: BAI, 1987.

Processing costs thus varied enormously, mainly because of:

(a) the writing-down of capital assets by rapid depreciation in the early years;

(b) the shortage of materials, spare parts and equipment in some years (e.g. 1984);

(c) the phasing out of much of the expatriate technical assistance staff from 1984 and a consequent reduction in staff costs;

(d) the variations in annual output.

Costs per tonne have ranged from US$ 35 to US$ 171, being highest in the early years. By comparison, factory costs quoted by BAI for a sample of other countries are as follows:

	Cost/tonne in 1979 dollars	Inflated to 1984 values*
Kenya	66	69
Mauritius	95	99
Sudan	183	190
Zambia	79	82

Note: * Taken as the mid-point of the JSP cost series in Table 6.3, applying the IBRD MUV world inflation factor.

Based on these data and on discussions with BAI staff, a reasonable estimate of factory costs excluding depreciation would be US$ 80/t, of which 40% (US$ 32) would be directly variable with the level of output (i.e. they would increase in direct proportion to sugar output). Most of these costs would be for sacks, chemicals and other consumables and spare parts, so the foreign exchange content would be high. Assuming a 75% FE content, the additional economic costs per tonne of sugar incurred in processing the additional JSP output resulting from Bardheere would be:

	Cost per tonne of sugar
Economic cost	SoSh 3 960
Direct FE cost	US$ 24

Table 6.4 shows the total increase in non-irrigation operating costs per year resulting from the expansion in JSP I output. At economic prices the increase would be SoSh 218 million, about one fifth of the increased output of SoSh 1 096 million. Direct FE costs would rise by US$ 1.16 million, as compared with the FE benefits of US$ 7.64 million.

TABLE 6.4

Increased Non-irrigation JSP I Costs per year due to Output Expansion Resulting from Bardheere

Item		Economic costs (SoSh million)	Direct FE costs (US$'000)
Additional output:			
- Cane 178 152 t			
- Sugar 18 827 t			
Additional costs:			
- irrigation labour:	117 840 days at SoSh 110/day	13.0	-
- harvesting labour:	260 362 days at SoSh 160/day	41.7	-
- cane loading:	11 134 hours	22.8	180.4
- cane transport:	32 391 hours	66.4	524.7
- factory operations:	32 391 hours	74.6	451.8
Total		218.5	1 156.9

6.1.3 Savings in Pumpset Maintenance and Depreciation

For calculation purposes it is assumed that the gravity supply canal now being built will obviate the need for pumping from the river for most of the year. Thus the pumpset savings will be only for sprinkler irrigation pumping and drainage pumping.

Total sprinkler irrigation pumping capacity for JSP I is 8 m^3/s, with a pumping head of 60 m. Due to this pumping head, capital costs per m^3/s of capacity are high, being estimated to be as follows:

	US$ per m^3/s	Total JSP I cost (US$)
Diesel motors	271 250	2 170 000
Electric motors	130 000	1 040 000

These figures include the pump as well as the motor. With an electric pumpset the pump and attachments typically account for roughly half the pumpset cost. On this basis the pump cost for both electric and diesel pumpsets has been taken to be US$ 65 000 per m^3/s, or US$ 520 000 for JSP I as a whole. Motor costs would then be as follows:

	Total JSP I costs (US$)
Diesel motors	1 650 000
Electric motors	520 000

Electric motors are simpler and cheaper to maintain and last much longer. Based on experience in similar environments elsewhere, an 8-year life has been assumed for diesels and 20 years for electric motors, with maintenance costs being the same as depreciation. Depreciation and maintenance costs per year for the motors would thus be:

	Motor maintenance and depreciation (US$)	FE %
Diesel	412 500	80
Electric	52 000	80

Total annual costs of the two types of motor would be as follows:

	Economic cost* (SoSh million)	FE % (US$)
Diesel	52.0	330 000
Electric	6.6	41 600
Savings	45.4	288 400

Note: * Savings with FE shadow priced at SoSh 135/US$.

Annual savings would thus be SoSh 45.4 million at economic prices, the direct FE savings being US$ 288 400. Rather than attempt to formulate a programme of motor replacement for JSP I and thus a year-by-year investment schedule, this sum has been put in to the analysis as the average annual benefit from 1995 onwards, the depreciation allowances taking account of the capital costs.

Savings would also be made on drainage pumpsets. By 1995 when a proper drainage system should have been installed throughout JSI, the estimated pumping capacity would be 7 m^3/s, with an average pumping head of 4 m. Capital costs would be as follows:

	US$/($m^3/s$)	JSP I total (US$)	Of which, cost of motor (US$)
Diesel pumpset	110 430	773 000	560 000
Electric pumpset	60 860	426 000	213 000

Taking the same depreciation and maintenance parameters as for sprinkler pumping, annual costs and savings would be:

	Motor maintenance and depreciation (US$)	Economic cost (SoSh million)	FE cost (US$)
Diesel	140 000	17.6	112 000
Electric	21 300	2.7	17 040
Annual saving	118 700	14.9	94 960

Total JSP I annual savings in pumpset maintenance and depreciation would thus be SoSh 60.3 million at economic prices, with direct FE savings being US$ 383 360.

6.1.4 Energy Costs

(a) Diesel Pumping (Without Bardheere)

The JSP 1987 budget assumes 12 irrigations per hectare and a total of 72 738 hectare - sprinkler irrigations. At 1 056 m^3 per irrigation (JSP estimate) this implies a total water use of 76.81 million m^3 at the sprinkler pump stations.

On the basis of normal engineering criteria and the JSP assumed sprinkler pumping head of 60 m, one litre of diesel fuel, which is equivalent to 3.3 kWh of electricity would pump 12.2 m^3. One irrigation of 1 056 m^3 therefore requires 87 litres or 286 kWh. With 72 738 hectare-irrigations the total annual consumption would be 6.328 million litres (20.882 million kWh). This is reasonably similar to the 6.395 million litres estimated by JSP in its 1987 budget (Table 14), although the latter figure does also cover drainage and irrigation supply pumping. Taking the 1987 budgeted situation as being the same as Forecast A and thus also the 'Without Bardheere' situation, diesel fuel economic costs would be:

Economic cost (SoSh 59/l)	SoSh 373.4 million
Direct FE cost (US$ 0.38/l)	US$ 2 404 640

Drainage pumping is likely to involve a lift of about 4 m, the output then being 185.2 m^3/l of diesel fuel or 56.1 m^3/kWh of electricity. JSP I is assumed to have eventually a total drainage pumping capacity of 7 m^3/s, operating for 2 000 hours per year. Total annual pumpage would then be 50.4 million m^3, requiring 272 140 l of diesel fuel (898 060 kWh of electricity), costing SoSh 16.0 million at economic prices and US$ 103 410 in direct FE.

Total 'Without Bardheere' JSP diesel fuel consumption and costs per year for irrigation and drainage would thus be:

Diesel fuel consumed	6.600 million litres
Economic cost	SoSh 389.4 million
Direct FE cost	US$ 2 508 050

All but 4% is attributable to sprinkler pumping.

(b) Electric Pumping (With Bardheere)

With 20 rather than 12 irrigations, the number assumed with Bardheere, total JSP I electricity consumption for sprinkler irrigation would be:

20.882 million KWh x 1.67 = 34.873 million kWh

With the addition of drainage pumping total consumption would be 35.771 million kWh, costing SoSh 214.6 million. Direct variable FE costs of hydro-electricity are assumed to be negligible, so no FE shadow pricing has been applied.

6.1.5 Total JSP I Benefits from Bardheere

Total annual benefits excluding energy cost savings are estimated to be SoSh 938 million at economic prices and US$ 6 870 000 in direct FE (Table 6.5). All but 6% of the economic benefits would come from the increase in sugar net output, but the contribution from savings in pumpset maintenance and depreciation (SoSh 60 million and US$ 0.38 million in FE) would still be significant.

Energy savings are difficult to value accurately in monetary terms, because they depend on the electricity price adopted. Nevertheless, the provision of HEP from Bardheere would save JSP I some 6.0 million litres in diesel fuel. In view of the periodic fuel shortages at JSP and in Somalia as a whole, this fuel saving would be of considerable benefit.

TABLE 6.5

Estimated JSP I Annual Benefits from Bardheere

Item	Economic prices (SoSh million)	Direct FE (US$ 000)
Production benefits per annum:		
- Increased sugar output	1 096	7 644
- Minus increased non-irrigation operating costs	218	1 157
Benefit	878	6 487
Savings in pumpset maintenance and depreciation	60	383
Total benefits	938	6 870
Energy costs:		
(a) Diesel pumping without Bardheere (6.00 million litres)	389.4	2 508
(b) Electric pumping with Bardheere (35.77 million kWh)	214.6	
Savings	174.8	2 508

6.2 Fanoole State Farm Project

As indicated in Tables 3.7 and 3.8, Bardheere is assumed to result in a 15% increase in rice cropping intensities in both the gu and der seasons, but no significant improvement in rice yields. With a net irrigable area of 4 000 ha the increase in crop area would be 1 200 ha per year. Based on Table 4.2 (crop net returns), annual benefits would be as follows:

	High Prices	Low Prices
At economic prices	SoSh 86 million	SoSh 40 million
Direct FE benefits	US$ 0.88 million	US$ 0.52 million

Since the increae in intensity per season is not large, the assumption made is that the full benefit would be attained in 1997, 2½ years after completion of the dam, the benefits in 1995 and 1996 being 40% and 80% of the full value.

6.3 Mogambo I and IIA

Bardheere would enable the Mogambo Project Phases I and IIA (3 385 ha) to convert from diesel to electric pumping and, due to removal of the jilaal water constraint and the greater security of pumping energy supplies, would result in an increase of 30% in annual cropping intensities.

6.3.1 Production Benefits

Table 6.6 shows the Bardheere production benefits for Mogambo I and IIA, based on 2 842 ha being under rice and 543 ha being under mixed cropping (163 ha of the latter would be under sprinkler irrigation).

Total Mogambo I and IIA production benefits from Bardheere are thus estimated to be SoSh 57.4 million (US$ 591 000 direct FE benefits) in the High Price scenario and SoSh 27.5 million (US$ 356 000 direct FE benefits) in the Low Price scenario. As for Fanoole, the build-up of these benefits would be 40% in 1995, 80% in 1996 and the full benefit thereafter.

6.3.2 Savings in Pumpset Maintenance and Depreciation

Annual sprinkler pumpset savings have been based on the values per hectare derived for JSP I (Section 6.1.3), which are SoSh 6 160 and US$ 39. With 163 ha under sprinkler irrigation in Mogambo I, total annual savings would be SoSh 1.0 million and US$ 6 360. Taking the JSP I drainage pumpset savings of SoSh 2 020/ha and US$ 13/ha, the savings for the 3 385 ha of Mogambo I and IIA would be SoSh 6.8 million and US$ 44 000. Total annual savings on drainage and sprinkler pumping would thus be:

At economic prices	SoSh 7.8 million
Direct FE savings	US$ 50 360

Total diesel pumpset capacity for Mogambo I and IIA for pumping irrigation water from the river would be 7.7 m^3/s comprising 3 x 2.2 m^3/s units and one 1.1 m^3/s unit. Capital costs would be US$ 672 000 as compared with US$ 440 000 for electric pumpsets. Based on the assumption made in Section 6.1.3 that the pump cost would be 50% of the total electric pumpset cost, the motor costs would be:

Diesel motors	US$ 452 000
Electric motors	US$ 220 000

Drainage pumping capacity is taken to be 3.8 m^3/s, comprising 2 x 1.2 m^3/s units and 2 x 0.7 m^3/s units. Capital costs would be US$ 308 800 for diesel pumpsets and US$ 213 300 for electric pumpsets; US$ 106 600 of this would be for the pumps, so motor costs would be US$ 202 200 (say US$ 202 000) and US$ 106 700 (say, US$ 107 000) respectively. Using the depreciation and maintenance factors applied in Section 6.1.3, total annual costs of the two types of motor would be:

	Capital costs (US$)	Maintenance and depreciation (US$)	Economic cost (SoSh million)	Direct FE cost (US$)
Diesel	654 000	163 500	20.6	130 800
Electric	327 000	32 700	4.1	26 160
Annual saving		130 800	16.5	104 640

Addition of the sprinkler irrigation and drainage pumpset savings would raise the annual benefits to SoSh 24.3 million at economic prices and US$ 155 000 in direct FE costs. As for JSP I, these benefits are assumed to accrue in full from 1995 onwards.

TABLE 6.6

Mogambo I and IIA Production Benefits from Bardheere[1]

	Economic returns (SoSh million)		Direct FE returns (US$ 000)	
	High Prices	Low Prices	High Prices	Low Prices
Without Bardheere				
Paddy rice:				
Returns/ha (SoSh 000)	55.7	22.5	$ 602	$ 340
Area (ha)	4 831	4 831	4 831	4 831
Total returns	269.1	108.7	2 908	1 643
Maize:				
Returns/ha (SoSh 000)	53.0	40.5	$ 463	$ 365
Area (ha)	277	277	277	277
Total returns	14.7	11.2	128	101
Pulses:				
Returns/ha (SoSh 000)	34.3	25.8	$ 310	$ 245
Area (ha)	168	168	168	168
Total returns	5.8	4.3	52	41
Sesame:				
Returns/ha (SoSh 000)	52.8	42.2	$ 409	$ 328
Area (ha)	223	223	223	223
Total returns	11.8	9.4	91	73
Cotton:				
Returns/ha (SoSh 000)	81.9	78.1	$ 779	$ 751
Area (ha)	223	223	223	223
Total returns	18.3	17.4	174	167
Vegetables:				
Returns/ha (SoSh 000)	252.0	210.1	-	-
Area (ha)	16	16	16	16
Total returns	4.0	3.4	-	-
Total net returns	323.7	154.4	3 353	2 025
With Bardheere				
Increased crop areas and net returns				
Paddy rice:				
Increased area (ha)	853	853	853	853
Increased returns	47.5	19.2	514	290
Maize:				
Increased area (ha)	49	49	49	49
Increased returns	2.6	2.0	23	18
Pulses:				
Increased area (ha)	27	27	27	27
Increased returns	0.9	0.7	8	7
Sesame:				
Increased area (ha)	38	38	38	38
Increased returns	2.0	1.6	16	12
Cotton:				
Increased area (ha)	38	38	38	38
Increased returns	3.1	3.0	30	29
Vegetables:				
Increased area (ha)	5	5	5	5
Increased returns	1.3	1.0	-	-
Total increase in net returns	57.4	27.5	591	356

Notes: (1) Cropping patterns are shown in Table 3.7 and net returns per hectare in Table 4.2.

6.3.3 Energy Costs

(a) Diesel Pumping Without Bardheere

JSP I annual drainage pumping is estimated to require 37 l/ha of diesel fuel or 122 kWh/ha of electricity. Applying the same figure for the 3 385 ha of Mogambo I and IIA, total diesel fuel consumption for drainage pumping would be 125 240 litres per year (or 412 970 kWh).

Full double cropping of rice is estimated to require 33 350 m^3/ha of water per year at the river pump station. Annual rice cropping intensity without Bardheere would be 170% rather than 200%, so annual water requirements would be 85% of this figure, or 28 350 m^3/ha per year. With 2 842 ha of land under rice cropping, total annual pumpage for this crop would be 80.57 million m^3.

Mixed cropping at 200% intensity would need 20 550 m^3/ha per year with surface irrigation and 13 020 m^3/ha with sprinkler irrigation (sprinkler irrigation efficiencies are much higher). Full double cropping of the 163 ha of sprinkler land and 380 ha of surface irrigated land under the mixed cropping system would thus need 9.93 million m^3. Due to the lower intensity without Bardheere (167%) total pumpage without Bardheere would be 83.5% of this, or 8.29 million m^3 per year. Total pumpage at the river pump station for Mogambo I and IIA would thus be 88.86 million m^3.

With an average lift of 5 m the output of the river pump station would be 48.2 m^3/l of diesel fuel (43.9 m^3/kWh). Annual fuel consumption would thus be 599 600 l.

For full double cropping water pumpage at the sprinkler pump station would be 11 720 m^3/ha, so with 167% intensity it would be 9 790 m^3/ha. Based on the JSP I figures in Section 6.1.4, one litre of diesel fuel or 3.3 kWh of electricity would pump 12.2 m^3 of water. With a sprinkler area of 163 ha and average annual water use of 9 790 m^3/ha total sprinkler pumpage would be 1.60 million m^3 and total diesel consumption would be 131 150 l (432 800 kWh).

Total consumption including drainage pumping would then be 855 990 l, the annual cost of which would be:

Economic cost (SoSh 59/l)	SoSh 50.5 million
Direct FE cost (US$ 0.38/l)	US$ 325 280

(b) Electric Pumping with Bardheere

Drainage pumping energy use would be more or less the same as without Bardheere, at 412 970 kWh per annum.

Based on the figures given in (a) above, sprinkler irrigation output would be 3.7 m^3 per kWh. Total sprinkler pumpage with Bardheere would be 1.91 million m^3 (163 ha x 11 720 m^3), in which case annual electricity consumption would be 516 220 kWh.

Total irrigation requirements at the river pump station with full double cropping (i.e. with Bardheere) would be as follows:

Cropping	Area (ha)	Requirement (m^3/ha)	Total (million m^3)
Rice area	2 842	33 350	94.78
Mixed cropping:			
- sprinkler	163	13 020	2.12
- surface	380	20 550	7.81
Total			104.71

With an output of 43.9 m^3/kWh, annual electricity consumption for river pumping would be 2 385 000 kWh. Total annual consumption would thus be 3.314 million kWh and the cost would be SoSh 19.9 million.

6.3.4 Total Mogambo I and IIA Benefits from Bardheere

Table 6.7 summarises the estimated Mogambo I and IIA benefits from Bardheere.

Annual economic benefits would be SoSh 82 million at High Prices and SoSh 52 million at Low Prices, the corresponding direct FE benefits being US$ 696 000 and US$ 461 000. Pumpset savings would account for half the benefits at Low Prices and almost one third at High Prices. Production benefits would therefore be relatively less important than at JSP. This is primarily because the 'without Bardheere' pumping energy situation is expected to be less serious than at JSP, so that the shortfall in irrigation supplies would be much less. Mogambo I and IIA diesel fuel consumption for irrigation and drainage would be modest compared with that at JSP (0.86 million litres compared with 6.0 million litres) and Mogambo's vulnerability to fuel shortages would be correspondingly less.

6.4 Existing Banana Areas

6.4.1 General

Without Bardheere the total Lower Juba area under bananas from 1995 onwards is expected to be 3 000 ha, with an additional 1 000 ha of fallow within the banana rotation. Bardheere would benefit this area very substantially, by eliminating the problems of low jilaal river flows, river water salinity during certain periods and flooding, and by enabling the farms to convert from diesel to electric pumping. This would save costs and also provide a more reliable supply of pumping energy.

Since the farmers are all concentrated in one area, along the river between Kamsuuma and Yoontoy, construction of an electricity distribution network to serve the pump stations, farms and other consumers should not be unduly difficult or expensive (see Section 6.6).

6.4.2 Production Benefits

As discussed in Section 2.5, accurate quantification of the production benefits to existing banana farms is not easy, because of the scarcity of reliable data. The informal Somalfruit estimate that export tonnages go down by as much as 30%

TABLE 6.7

Estimated Mogambo I and IIA Annual Benefits from Bardheere

	Economic prices (SoSh million)		Direct FE benefits (US$ 000)	
	High Prices	Low Prices	High Prices	Low Prices
Production benefits (Table 6.6)	57.4	27.5	591	356
Savings in pumpset maintenance and depreciation	24.3	24.3	105	105
Total benefits	81.7	51.8	696	461
Energy costs				
(a) Diesel pumping without Bardheere (856 000 litres)	50.5		325.3	
(b) Electric pumping with Bardheere (3.314 million kWh)	19.9			
Savings	30.6			

TABLE 6.8

Estimated Production Benefits from Bardheere on Existing Banana Farms

	Economic benefits (SoSh million)		Direct FE benefits (US$ 000)	
	High Prices	Low Prices	High Prices	Low Prices
Returns per ha of bananas (Table 4.2)				
- with Bardheere	436 900	344 100	5 633	4 606
- without Bardheere	316 900	242 700	4 337	3 516
Bardheere benefit	120 000	101 400	1 296	1 090
Total benefits on 3 000 ha of bananas	360.0	304.2	3 888	3 270

in a bad jilaal seems, however, reasonably realistic. We have therefore taken the middle of this range (20%) and have assumed that without Bardheere gross returns per hectare will be 20% below those with Bardheere. Apart from the direct effects on yields and quality, this figure is considered to take account also of the various other factors involved, such as increased replanting costs resulting from plant deaths caused by the jilaal and with Bardheere, farmers' increased enthusiasm and willingness to invest in their farms as a result of the elimination of the jilaal and, flooding problems.

Table 6.8 shows the estimated production benefits from Bardheere for existing banana farms.

6.4.3 Savings in Pumpset Maintenance and Depreciation

Savings have been calculated on the basis of a farm with 50 ha of bananas and another 15 ha fallowed. The total pumping capacity required in the future, with Bardheere, would be 20 l/s, with an average head of 5 m. Due to the present oversizing of pumpsets the existing diesel sets are assumed to have an average capacity of 170 l/s and also to need to be able to cope with a greater pumping head (6 m) because of the lower river levels in much of the year, without Bardheere.

Capital costs of a 170 l/s diesel pumpset would be US$ 17 400 as compared with US$ 13 800 for a 120 l/s electric pumpset. Deduction of the pump cost of US$ 6 900 (half the electric pumpset cost) would mean a cost of US$ 10 500 for the diesel engine and US$ 6 900 for the electric motor and attachments. Annual sts would be as follows:

	Capital costs (US$)	Maintenance and depreciation (US$)	Economic cost (SoSh)	Direct FE cost (US$)
Diesel	10 500	2 625	330 750	2 100
Electric	6 900	690	86 940	552
Annual saving		1 935	243 810	1 548
Saving per ha			4 876	31

With 3 000 ha of bananas, annual pumpset savings would be SoSh 14.6 million at economic prices and US$ 93 000 in direct FE. As with JSP I and Mogambo, these benefits would be obtained from 1995 onwards.

6.4.4 Energy Costs

Annual water requirements for bananas are estimated to be 33 350 m^3/ha at the river pump station. Taking the same average lift as for Mogambo (5 m) and the resultant pumping output of 43.9 m^3/kWh, total electricity consumption for 3 000 ha of bananas receiving full irrigation (i.e. with Bardheere) would be 2.279 million kWh and the total electricity cost would be SoSh 13.7 million per annum.

At 3.3 kWh per litre of diesel fuel the equivalent fuel consumption with diesel pumping would be 690 600 l. It is difficult to say whether pumping hours 'without Bardheere' would be more or less than Bardheere. On the one hand there are stoppages of pumping in the jilaal due to lack of water in the river, but on the other hand the water output per pumping hour in the jilaal is less than in the rest of the year, because of the greater lift. In the absence of reliable data on actual pumpage, diesel fuel consumption without Bardheere has been taken to be the same figure as is quoted above, 690 600 l per annum. Economic and direct FE costs would then be SoSh 40.7 million and US$ 262 430.

6.4.5 Total Annual Bardheere Benefits from Existing Banana Farms

Table 6.9 summarises total annual Bardheere benefits from existing banana farms.

Annual economic benefits would be SoSh 375 million and SoSh 319 million at High and Low Prices respectively, the corresponding direct FE benefits being US$ 3 981 000 and US$ 3 363 000. Since Bardheere would not come on stream until the 1995 gu season the first production benefits would be received in 1996. They would reach their full value in 1997, the value in 1996 being 50% of this full value. Virtually all the benefit would be a result of the expected increase in banana production and exports resulting from Bardheere. These relatively high benefits are a reflection of the large area of bananas that will benefit from Bardheere (3 000 ha), the high per hectare yields and net returns from this crop and the depressing effect that the jilaal water shortages and seasonal water quality problems have on present (without Bardheere) production.

Savings in diesel fuel consumption would amount to some 0.69 million litres, a substantial figure.

6.5 Existing Small-Scale Private Pump Irrigation

Without Bardheere the area under small-scale private pump irrigation between the dam and the coast is assumed to rise from 3 330 ha in 1995 to 5 330 ha from 2005 onwards (Table 3.2). The main effect of Bardheere on this area would be to bring about a slight increase in annual cropping intensity from 200% to 225%, of which 10% would be for rice and 15% for vegetables.

Some pump schemes would probably convert from diesel to electric pumping, with a resultant saving in pumpset maintenance and depreciation and pumping energy costs. In view, however, of the scattered distribution of the pump schemes and the substantial cost of installing electricity distribution systems this may be a fairly gradual process; benefits from conversion to electric pumping have therefore not been included in the analysis.

Table 6.10 shows the calculation of Bardheere production benefits from existing small-scale private pump schemes, before deduction of the additional diesel pumping costs. Applying the same rice water requirements as for Mogambo, 21 660 m^3 per crop hectare, the additional pumpage for rice would be 7.21 million m^3 in 1995 and 11.54 million m^3 in 2005. At 8 050 m^3 per crop hectare the extra pumpage for vegetables would be 4.02 million m^3 and 6.43 million m^3 respectively. With an average lift of 5 m, the same as for Mogambo and existing banana farms, pumping output would be 148.2 m^3/l of diesel fuel and total additional consumption and costs with Bardheere would be:

	1995	2005
Total pumpage	11.2 million m^3	17.97 million m^3
Fuel consumption	75 780 l	121 260 l
Economic cost at SoSh 59 per litre (SoSh million)	4.47	7.15
Direct FE cost at US$ 0.38 per litre	US$ 28 800	US$ 46 080

TABLE 6.9

Estimated Annual Bardheere Benefits from Existing Banana Farms

	Economic prices (SoSh million)		Direct FE benefits (US$ 000)	
	High Prices	Low Prices	High Prices	Low Prices
Production benefits				
(Table 6.8)	360.0	304.2	3 888	3 270
Savings in pumpset maintenance and depreciation	14.6	14.6	93	93
Total benefits	374.6	318.8	3 981	3 363
Energy costs				
- diesel pumping with Bardheere (690 600 litres)	40.7		262.4	
- electric pumping with Bardheere (2.279 million kWh)	13.7			
Saving	27.0		262.4	

TABLE 6.10

Estimated Annual Bardheere Production Benefits from Existing Small-Scale Private Pump Irrigation

	1995			2005		
	Rice	Vegetables	Total	Rice	Vegetables	Total
Total irrigated area (ha)		3 330			5 330	
Increase in crop areas (see Table 3.7	333	499	832	533	799	1 332
A. High Price Scenario						
1. Economic Benefits						
Net return/ha in SoSh 000 (Table 4.2)	56.8	176.6	-	56.8	176.6	
Total net returns (SoSh million)	18.9	88.1	107.0	30.3	141.1	171.4
2. Direct FE Benefits						
Net return/ha ($) (Table 4.2)	599	-	-	599	-	-
Total net returns ($ 000)	199.5	-	199.5	319.3	-	319.3
B. Low Price Scenario						
1. Economic Benefits						
Net return/ha in SoSh 000	28.4	146.6	28.4	146.6		
Total net returns (SoSh million)	9.5	73.2	82.7	15.1	117.1	132.2
2. Direct FE Benefits						
Net return/ha ($)	374	-		374	-	
Total net returns ($ 000)	124.5	-	124.5	199.3	-	199.3

Increased costs of lubrication, depreciation and maintenance would not be very substantial. For analysis purposes they are assumed to be equal to the value of the savings achieved on those pumpsets which are converted from diesel pumping to electricity.

After deduction of fuel costs, total annual Bardheere benefits on existing pumping schemes would be as follows:

	1995	2005
1. Low Price scenario:		
- Economic benefits (SoSh million)	78.2	125.1
- Direct FE benefits (US$ 000)	95.7	153.2
2. High Price scenario		
- Economic benefits (SoSh million)	102.5	164.2
- Direct FE benefits (US$ 000)	170.7	273.2

An even annual build-up in benefits between 1995 and 2005 is assumed, after which they would remain the same. However, to allow for a progressive build-up in returns and the fact that Bardheere would not come on-stream until just after the 1995 gu season, the benefit streams in Tables 6.9 to 6.12 assume a one-year delay in benefits, the first being received in 1996 and the full value being reached in 2006.

6.6 Total Bardheere Benefits from Existing Irrigation

Tables 6.11 to 6.14 show the total year-by-year Bardheere economic benefits and direct FE benefits from existing irrigation schemes at High and Low Prices for the 1995 to 2035 analysis period. These figures exclude the value of net savings in energy costs resulting from the conversion from diesel to electric pumping.

According to these estimates annual economic benefits at High Prices would reach SoSh 1 644 million by 2006, the corresponding figure at Low Prices being about 10% lower, at SoSh 1 473 million. At a 10% discount rate the present values of the 1995 to 2035 benefits would be SoSh 14 763 million and SoSh 13 299 million respectively. Taking the High Price scenario as the more realistic, 94% of the annual benefits from 1997 onwards would be from increased production on the existing schemes and 6% would come from savings on pumpset maintenance and depreciation due to electrification.

The main benefits would come from increased sugar output on JSP I (53% of the total) and the banana farms (22% of the total). Both suffer severely from irrigation water shortages at present, due mainly to inadequate supplies of diesel fuel (JSP I) and the effects of the low jilaal flows (the banana farms). Since both sugar cane and bananas have a high yield potential and high net economic returns per hectare, the alleviation of these irrigation water constraints through construction of Bardheere would produce very substantial economic benefits. In both cases the schemes are already well established and the infrastructure and services necessary for higher productivity are already in place, which means that a major expansion in output can be achieved at relatively little additional cost.

Direct FE benefits would also be very substantial, reaching US$ 12.7 million per annum at High Prices and US$ 11.4 million per annum at Low Prices. Again JSP I and the banana farms would account for most of the benefits (90%). JSP's increased sugar output would directly replace imports and the additional bananas produced would be exported.

TABLE 6.11

Bardheere Annual Economic Benefits from Existing Irrigation Schemes at High Prices (SoSh million at 1987 constant prices)

Year	Production benefits						Pumpset savings				Total
	JSP I	Fanoole	Mogambo I and IIA	Banana farms	Small pump schemes	Total	JSP I	Mogambo I and IIA	Banana farms	Total	
1995	439	34	23	-	-	496	60	24	15	99	595
1996	878	69	46	180	102	1 275	60	24	15	99	1 374
1997	878	86	57	360	108	1 489	60	24	15	99	1 588
1998	878	86	57	360	114	1 495	60	24	15	99	1 594
1999	878	86	57	360	120	1 501	60	24	15	99	1 600
2000	878	86	57	360	126	1 507	60	24	15	99	1 606
2001	878	86	57	360	132	1 513	60	24	15	99	1 612
2002	878	86	57	360	138	1 519	60	24	15	99	1 618
2003	878	86	57	360	144	1 525	60	24	15	99	1 624
2004	878	86	57	360	150	1 531	60	24	15	99	1 630
2005	878	86	57	360	157	1 538	60	24	15	99	1 637
2006 to 2035	878	86	57	360	164	1 545	60	24	15	99	1 644

Present values at 1994 (Year 0):
Discount rate:

5%	26 970
10%	14 763
15%	9 673

TABLE 6.12

Bardheere Annual Economic Benefits from Existing Irrigation Schemes at Low Prices (SoSh million at 1987 constant prices)

Year	Production benefits						Pumpset savings				Total
	JSP I	Fanoole	Mogambo I and IIA	Banana farms	Small pump schemes	Total	JSP I	Mogambo I and IIA	Banana farms	Total	
1995	439	16	11	-	-	466	60	24	15	99	565
1996	878	32	22	152	78	1 162	60	24	15	99	1 261
1997	878	40	27	304	82	1 331	60	24	15	99	1 430
1998	878	40	27	304	86	1 335	60	24	15	99	1 434
1999	878	40	27	304	90	1 339	60	24	15	99	1 438
2000	878	40	27	304	94	1 343	60	24	15	99	1 442
2001	878	40	27	304	99	1 348	60	24	15	99	1 447
2002	878	40	27	304	104	1 353	60	24	15	99	1 452
2003	878	40	27	304	109	1 358	60	24	15	99	1 457
2004	878	40	27	304	114	1 363	60	24	15	99	1 462
2005	878	40	27	304	119	1 368	60	24	15	99	1 467
2006 to 2035	878	40	27	304	125	1 374	60	24	15	99	1 473

Present values at 1994 (Year 0):

Discount rate:	
5%	24 244
10%	13 299
15%	8 732

TABLE 6.13

Bardheere Annual Direct Foreign Exchange Benefits from Existing Irrigation Schemes at High Prices (US$ 000 at 1987 constant prices)

Year	Production benefits						Pumpset savings				Total
	JSP I	Fanoole	Mogambo I and IIA	Banana farms	Small pump schemes	Total	JSP I	Mogambo I and IIA	Banana farms	Total	
1995	3 243	352	236	-	-	3 831	383	105	93	581	4 412
1996	6 487	704	473	1 944	171	9 779	383	105	93	581	10 360
1997	6 487	880	591	3 888	181	12 027	383	105	93	581	12 608
1998	6 487	880	591	3 888	191	12 037	383	105	93	581	12 618
1999	6 487	880	591	3 888	201	12 047	383	105	93	581	12 628
2000	6 487	880	591	3 888	211	12 057	383	105	93	581	12 638
2001	6 487	880	591	3 888	221	12 067	383	105	93	581	12 648
2002	6 487	880	591	3 888	231	12 077	383	105	93	581	12 658
2003	6 487	880	591	3 888	241	12 087	383	105	93	581	12 668
2004	6 487	880	591	3 888	251	12 097	383	105	93	581	12 678
2005	6 487	880	591	3 888	262	12 108	383	105	93	581	12 689
2006 to 2035	6 487	880	591	3 888	273	12 119	383	105	93	581	12 700

Present values at 1994 (Year 0):	
Discount rate:	
5%	209 267
10%	114 706
15%	75 195

TABLE 6.14

Bardheere Annual Direct Foreign Exchange Benefits from Existing Irrigation Schemes at Low Prices (US$ 000 at 1987 constant prices)

Year	Production benefits						Pumpset savings				Total
	JSP I	Fanoole	Mogambo I and IIA	Banana farms	Small pump schemes	Total	JSP I	Mogambo I and IIA	Banana farms	Total	
1995	3 243	208	142	-	-	3 593	383	105	93	581	4 174
1996	6 487	416	285	1 635	96	8 919	383	105	93	581	9 500
1997	6 487	520	356	3 270	103	10 736	383	105	93	581	11 317
1998	6 487	520	356	3 270	108	10 741	383	105	93	581	11 322
1999	6 487	520	356	3 270	113	10 746	383	105	93	581	11 327
2000	6 487	520	356	3 270	119	10 752	383	105	93	581	11 333
2001	6 487	520	356	3 270	125	10 758	383	105	93	581	11 339
2002	6 487	520	356	3 270	131	10 764	383	105	93	581	11 345
2003	6 487	520	356	3 270	137	10 770	383	105	93	581	11 351
2004	6 487	520	356	3 270	143	10 776	383	105	93	581	11 357
2005	6 487	520	356	3 270	148	10 781	383	105	93	581	11 362
2006 to 2035	6 487	520	356	3 270	153	10 786	383	105	93	581	11 367

Present values at Year 0 (1994):	
Discount rate:	
5%	187 850
10%	103 155
15%	67 748

At High Prices the total present value of the FE benefits from existing irrigation schemes would be US$ 114.7 million at a 10% discount rate. This would be sufficient to meet a very substantial proportion of the capital costs of Bardheere dam, which have been estimated to total US$ 300 to US$ 400 million, by no means all of which would be FE. If, as mentioned in Section 1.1, the hydro-electric benefits are expected to be large enough to meet at least two-thirds of the dam costs, the implication is that the Bardheere benefits from existing irrigation schemes would be sufficient to meet the rest.

6.7 Diesel Fuel Savings Due to Bardheere

Electrification of irrigation and drainage pumping on existing irrigation schemes would result in a large reduction in diesel fuel consumption, as shown in Table 6.15. Total net savings would be about 7.4 million litres per annum. In view of the frequent scarcity of diesel fuel in Somalia, the release of these supplies for use elsewhere in the economy (e.g. for road transport and agricultural machinery operations) would be highly beneficial.

TABLE 6.15

Savings in Diesel Fuel Consumption for Irrigation and Drainage Pumping on Existing Irrigation Schemes

Scheme	Million litres per annum
JSP I (Table 6.5)	6.00
Mogambo I and IIA (Section 6.3.3)	0.86
Banana farms (Table 6.7)	0.69
Total	7.55
Minus: Increased consumption on small-scale private pump schemes at Year 2005 onwards (Section 6.5)	0.12
Net saving	7.43

6.8 Electricity Distribution in the Main Existing Irrigation Zones in the Lower Juba Valley

6.8.1 Introduction

Achievement of much of the Bardheere benefits quantified in Section 6.7 will depend on an adequate electricity distribution network being constructed to serve the major existing irrigated areas in the Lower Juba. A broad estimate of likely electrification costs has therefore been made. At this stage it is not possible to draw up a detailed electrification plan for costing purposes, especially as much will depend on the findings of the forthcoming AHT master planning study and other work. Nevertheless, our estimates are sufficiently detailed to give a reasonable impression of the possible costs.

6.8.2 Costing Assumptions

The main assumptions made for costing purposes are as follows:

(i) As described in the Bardheere Detailed Design Report by Electroconsult (March 1986), there would be a 220 kV power line running from the dam site to Kismayo (343 km).

(ii) In the main region being considered in the assessment of Bardheere agricultural benefits, that between just upstream of Jilib and downstream of Jamaame, the principal areas to be provided with electricity would be:

- JSP I and II, with a peak power demand of some 20 MW. This figure is derived from BAI calculations for JSP I;
- The numerous banana farms in the 30 to 40 km stretch between Kamsuuma and just downstream of Jamaame;
- The existing Mogambo Phase I scheme and proposed Phase II developments;
- the towns of Jilib, Kamsuma and Jamaame and the villages in the area.

For costing purposes it is assumed that a spur 220 kV line would take off from Jilib and cross the river to serve JSP, running through to the factory, for an estimated distance of 20 km. Near the factory there would be a 220 kV/33 kV sub-station, from which single 33 kV lines would run along the main canal to the northern and southern ends of the joint JSP I/JSP II area. Total length would be some 75 km. Along this line there would be about 30 to 33 kV/440 V sub-stations, with 120 km of 440 V lines serving pump stations and other consumers. All the sub-stations would be of 500 kVA capacity.

A 33 kV line would take off from the 33 kV/220 kV sub-station already proposed by Electroconsult for Jilib and would run along or near to the main Kismayo road southwards at least as far as several kilometres downstream of Jamaame (i.e. to serve all the banana areas), a distance of some 70 km. A spur line of several kilometres length would serve the Mogambo project, the total length of 33 kV line thus being 75 km. Along this 75 km there would be fifty 33 kV/440 V sub-stations, twenty of which would be 100 kVA, ten 250 kVA and twenty 500 kVA. There would be a total of 175 km of 440 V line leading from these sub-stations.

6.8.3 Electrification Costs

Unit rates for the various components in this distribution network have been derived from the Electroconsult 1986 report and from recent studies done by MMP for other African countries. Table 6.16 shows the resultant capital costs. Account has not been taken of the possible contribution which could be made by the existing power line running southwards from the Fanoole hydropower station and the costs of the Jilib proposed 220 kV/33 kV station are not included.

Total costs are estimated to be about US$ 6.81 million, of which US$ 5.11 million would be FE. With FE shadow pricing the economic capital cost would be SoSh 843 million. This is negligible in comparison with the annual economic benefits of at least SoSh 1 473 million (Table 6.10 for the Low Price scenario) and is equivalent to only 6% of the total present value of those benefits at a 10% discount rate.

TABLE 6.16

Capital Costs of New Electricity Distribution Systems between Jilib and Downstream of Jamaame

Item	Unit	Unit rate (US$)	Quantity	Total cost (US$ '000)
1. Transmission lines				
220 kV line	km	70 000	20	1 400
33 kV line (metal towers)	km	15 000	150	2 250
440 V line (wooden poles)	km	2 000	295	590
Sub-total				4 240
2. Sub-stations				
220 kV/33 kV	Nr	1 500 000	1	1 500
33 kV/440 V				
- 100 kVA	Nr	8 000	20	160
- 250 kVA	Nr	11 000	10	110
- 500 kVA	Nr	16 000	50	800
Sub-total				2 570
3. Total costs				6 810

Equivalent in SoSh - SoSh 612.9 million
FE content - 75%
Economic cost with FE shadow pricing - SoSh 842.7 million

CHAPTER 7

BENEFITS FROM THE DEVELOPMENT OF NEW IRRIGATION SCHEMES

7.1 General

Benefit and costs from the development of new irrigation have been calculated for the following:

- New areas of irrigated bananas;
- Other new areas of private pump irrigation;
- Juba Sugar Project Phase II;
- Homboy Irrigation Project
- Mogambo IIB;
- Other large-scale Government projects.

The likelihood of these new developments taking place varies widely from category to category. A major expansion of the private banana farms can be predicted with confidence, because the 'without Bardheere' area of 3 000 ha is far below the historical maximum in the Lower Juba, bananas are a highly profitable crop and, even now, despite the flooding and jilaal low flow problems, the industry is expanding. Removal of these constraints should encourage a marked increase in banana production. Moreover, being almost entirely a private sector activity, it does not suffer so much from the financial and institutional constraints which hinder public sector development.

Similar arguments apply in the case of small-scale pump irrigation. This is already expanding, with little direct Government assistance, and can be expected to continue to increase, even if Government makes no special efforts to accelerate its development. Provision of additional medium-term credit for pumpset purchase and scheme construction would, however, stimulate expansion.

In principle, therefore, substantial benefits from new private irrigation development can be expected even with no direct Government action other than the construction of the dam itself, the electrical distribution system in the valley and the main road from Jilib to the dam site (this will be required anyway, for the construction of the dam).

Juba Sugar Project is now a well-established scheme which, considering the severe shortages of fuel and other inputs under which it has operated, has proved reasonably successful. There seems little doubt that it could be expanded into a second phase, provided that finance could be obtained. By 1995 the internal market should be large enough to absorb the additional sugar output. Difficulty could, however, be experienced in finding sufficient land within economic reach of the factory. In the original studies it was envisaged that the 6 300 ha required would be located to the north and south of JSP I, which would result in longer cane haulage distances than for JSP I. A better alternative might be to build a bridge across the river Juba near Jilib and develop the land on the left bank, much of which would be suitable for surface irrigation. The practicability of this option would depend, however, on the future expansion of Fauoole, because most of the suitable land is earmarked for that scheme.

At this stage it is not possible to forecast where exactly JSP II would be sited. For analysis purposes a compromise solution has been adopted, therefore, whereby sprinkler irrigation would be installed (i.e. this represents right bank rather than left bank conditions), but cane haulage distances would be the same as for JSP I (this implies that JSP II would be on the left bank). Irrigation supply from the river would be by gravity canal.

The remaining new irrigation developments being considered in the analysis are large Government projects. Mogambo IIB is unlikely to be economic, because of its high capital and recurrent costs. Since its soils and topographic conditions preclude the use of surface irrigation Mogambo IIB will have to use sprinkler irrigation, which is much more expensive. Homboy and other large projects could produce satisfactory crop benefits, but this will depend on the extent to which double cropping and high yields can be achieved and on the successful management of the projects and their farmers. Neither Mogambo IA nor Fanoole have yet come near their original cropping and production targets.

Attainment of the projected benefits from large Government projects is therefore considered to be less certain than in the case of private irrigation and JSP II.

Agricultural benefits from new irrigation development have been based on the prices and returns shown in Chapter 4 and the estimates made for existing irrigation schemes in Chapter 6. Costs have been based on experience with recent construction contracts in Somalia (e.g. Mogambo IA and JSP I), the Homboy estimates and data from irrigation projects in similar conditions elsewhere. Although the estimates are approximate in nature they are considered to be reasonably realistic and to be adequate for the purposes of this broad assessment of Bardheere benefits.

7.2 New Areas of Irrigated Bananas on Private Schemes

7.2.1 General

As for existing banana farms, costing has been based on an area of 65 ha, with 50 ha under bananas at any one time. Construction standards and the level of facilities and infrastructure provided would be similar to those applied on the better banana farms at present. A gravity drainage system, a low-cost road system, buildings and other facilities would be constructed and the land would be levelled for efficient surface irrigation. Once full production is reached the yields and net returns would be the same as for existing farms (see Section 6.4).

7.2.2 Capital Costs

Table 7.1 summarises the capital costs per hectare. These figures are based on data from the other cost estimates made in this study and from AHT's 1984 report on existing deshek and irrigated farming.

At US$ 2 530 per ha the capital costs are much lower than for large Government schemes, though considerably higher than those for small-scale private irrigation (US$ 440 per hectare). The reasons for costs being lower than for large Government schemes include:

- Much of the construction work is done cheaply by the farmer himself, using his own equipment or that hired in from other farmers, and large contracting companies are rarely employed.

- With the relatively small size of scheme, simple pump stations, comprising only a pumpset, piping and discharge box, are sufficient, whereas large projects like Mogambo and JSP need pump stations involving major civil works, inlet channels, draglines for dredging these channels, etc.

- Most farmers deliberately economise on what they consider to be non-essential facilities and services, such as offices.

- Most of the new banana areas would probably be extensions to existing farms rather than new farms, so there would be savings in the costs of certain facilities and equipment (e.g. vehicles).

TABLE 7.1

Capital Costs Per Hectare for New Banana Land Under Private Schemes, at 1987 Constant Prices

Item	Total cost (US$)	FE (per cent)	FE cost (US$)
Buildings and services	250	25	62
Unsurfaced road	100	50	50
Bush clearance, land levelling, harrowing	1 000	60	600
Irrigation and drainage system	250	70	175
Irrigation pumping station (120 l/s electric pumpset plus civil works, piping, etc.)	500	75	375
Vehicles and machinery (excluding tractors and other agricultural machinery)(1): say,	200	85	170
Miscellaneous costs and contingencies (10%)	230	-	143
Total in US$	2 530	62	1 575
Economic cost	SoSh 298 575		

Note: (1) Agricultural machinery is not included, because its capital costs are taken into account in the tractor costs in the crop budgets.

7.2.3 Recurrent Costs

(a) Pumpset costs:

Annual depreciation and maintenance for an electric pumpset costing US$ 13 800 (see Section 6.4.3), would be 10%, or US$ 1 380. With an 80% FE content direct FE costs would be US$ 1 100 and economic costs would be SoSh 174 900; costs per ha of irrigable land (65 ha) would then be US$ 17 and SoSh 2 700 respectively.

(b) Pumping Electricity Costs:

Based on the figures presented in Section 6.4.4, average annual water requirements for 50 ha of bananas would be 1 667 500 m^3 at the river pump station and total consumption of pumping electricity would be 37 984 kWh. At

SoSh 6/kWh the total cost would be SoSh 227 900, or SoSh 3 500 per hectare of irrigable land. This does not include the irrigation of annual crops on the fallow land - the costs and benefits of these crops have been excluded from the analysis.

(c) Other Costs:

Somalfruit estimate other recurrent costs to be as follows:

Item	SoSh/ha of bananas (50 ha/farm)	SoSh/ha of banana farm (65 ha farm)
Management	12 000	
Cleaning:		
Drains	4 400	
Canals	6 000	
Total	22 400	17 230

Allowance should also be made for maintaining buildings, roads and non-agricultural vehicles and machinery. The total capital cost of these items (see Table 7.1) is US$ 550 per hectare. At 10% of this sum, annual maintenance costs would be US$ 55 per hectare (SoSh 4 950 per hectare).

Based on these estimates, Table 7.2 shows the total recurrent costs per hectare of banana land. These would reach their full level in the second year after development begins, being 50% of this level in the first year.

TABLE 7.2

Recurrent Costs Per Hectare for New Banana Land Under Private Schemes, Excluding Crop Production Costs (SoSh)

Item	Cost	Direct FE cost (US$)	Economic cost
Pumpset depreciation and maintenance	1 900	17	2 700
Pumping electricity	3 500		3 500
Management and irrigation and drainage maintenance	17 230	57(30%)	19 810
Other maintenance	4 950	17(30%)	5 690
Miscellaneous costs (10%)	2 760	3(30%)	3 170
	30 360	94	34 870

7.2.4 Benefits

With the net return per hectare shown in Table 4.2 and 0.77 ha of bananas per hectare of irrigable land (i.e. 50 ha of bananas on 65 ha total area) net returns per hectare would be:

1. High Prices

- Economic benefit	SoSh	336 400
- Direct FE benefit	US%	4 337

2. Low Prices

- Economic benefit	SoSh	265 000
- Direct FE benefit	US$	3 547

The build-up of these benefits on a hectare of new banana land is assumed to be as follows:

Year	Percentage of full benefit
1 (construction and planting year)	-
2	40
3	80
4 onwards	100

A rapid build-up can be expected, because most of the new banana land is likely to be developed by existing growers who already have considerable experience of banana growing.

7.2.5 Total Benefits and Costs From New Areas of Private Banana Schemes

As described in Section 3.6.3, the assumption made is that, with Bardheere, the private banana farm area would expand by 586 ha per year from 1995 to 1999, the total new area being 2 930 ha. With 75% of this being under bananas and 25% under fallow, the banana area would be 2 200 ha.

Total economic net benefits from the development of new private banana land owuld be very high (see Table 7.3), reaching SoSh 883 million per annum and SoSh 674 million per annum at High and Low prices respectively. At a 10% discount rate the present value of net benefits as at 1994 would be SoSh 5 288 million and SoSh 3 856 million respectively. These very high benefits are a result of the relatively low capital and recurrent costs of expanding the area of private banana farms and the fact that bananas are a very profitable crop, with high FE returns, since most of the additional output would be exported.

TABLE 7.3

Annual Economic Benefits and Costs from New Areas of Private Banana Production
(SoSh million at 1987 constant prices)

Year	Irrigated area (ha) New land	Irrigated area (ha) Cumulative area	FE costs Capital (1)	FE costs Recurrent (2)	FE costs Total	FE benefits High Prices	FE benefits Low Prices	Net cash flow High Prices	Net cash flow Low Prices
1995	586	586	175.0	10.2	185.2	-	-	(185.2)	(185.2)
1996	586	1 172	175.0	30.6	205.6	78.9	62.2	(126.7)	(143.4)
1997	586	1 758	175.0	51.1	226.1	236.6	186.4	10.5	(39.7)
1998	586	2 344	175.0	71.5	246.5	433.7	341.6	187.2	95.1
1999	586	2 930	175.0	91.9	266.9	630.8	496.9	363.9	230.0
2000	-	2 930	-	102.2	102.2	827.9	652.2	725.7	550.0
2001	-	2 930	-	102.2	102.2	946.2	745.4	844.0	643.2
2002 to 2035	-	2 930	-	102.2	102.2	985.7	776.5	883.5	674.3

Net present values at year 0 (1994):	High Prices	Low Prices
Discount rate		
5%	11 465.6	8 545.1
10%	5 287.7	3 856.4
15%	2 864.2	2 028.1
Internal rates of return	65%	52%

Notes:
(1) SoSh 298 575/ha (Table 7.1) multiplied by the number of hectares of new land.
(2) At SoSh 34 870/ha (Table 7.2), and only 50% of these costs in the first year of development.

This is reflected in the annual net FE benefits shown in Table 7.4. By the year 2007 these are estimated to reach US$ 12.4 million and US$ 10.1 million at High and Low prices respectively, present values at a 10% discount rate being US$ 81.3 million and US$ 65.5 million. These would be slightly reduced if the electricity used for pumping were assumed to have some direct FE cost, but the reduction would not be great.

These economic and FE benefit estimates could be regarded as fairly conservative in terms of the additional private banana area which would be developed in the future (2 930 ha). Due to expected export market constraints, the total expansion in bananas in the Lower Juba resulting from Bardheere has been assumed to be confined to 6 430 ha, of which 3 500 ha would be on the Homboy and Smallholder Banana Pilot Projects. If these two government projects did not go ahead or had reduced areas of bananas a greater expansion of private banana farms would be possible, within the overall limit set by the size of the future export market. Benefits from the expansion of private banana farms would then be correspondingly greater.

7.3 Expansion of Other Private Pump Irrigation

7.3.1 General

Based on Tables 3.2 and 3.6, the expansion of small-scale private pump irrigation due to Bardheere has been assumed to total 8 800 ha by the year 2005, the increase being at a rate of 800 ha per year over the 1995 to 2005 period.

7.3.2 Capital and Recurrent Costs

Costing for small-scale private irrigation development has been based on a farm of 5 ha net irrigable area growing the mixed cropping pattern shown in Table 3.7, with an annual cropping intensity of 225%. Such farms normally have 20 to 30 l/s diesel-driven mobile pumpsets and a simple irrigation distribution system built with hand labour. Due to their scattered distribution, most of these pump schemes are unlikely to be electrified for many years, so the costing assumes diesel rather than electric pumping.

(a) Capital Costs

Capital costs are estimated to be as follows:

Diesel pumpset (20 to 30 l/s)	US$ 1 600 (80% FE)
Pump station civil works (outlet box etc.) : 20% of pumpset cost	US$ 320 (40% FE)
Construction of irrigation distribution system by the farmer and other labour: say, 50 man days/ha at the economic price of labour of SoSh 110/day	SoSh 27 500

Total economic costs would thus be SoSh 200 000 without FE shadow pricing, or SoSh 40 000 (US$ 441 at the official exchange rate) per ha. With FE shadow pricing they would be SoSh 263 000, or SoSh 52 600/ha. FE costs would be US$ 1 408, or US$ 282/ha.

TABLE 7.4

Annual Direct Foreign Exchange Benefits from New Areas of Private Banana Production (US$ '000 at constant 1987 prices)

Year	Irrigated area (ha)		FE costs			FE benefits		Net cash flow	
	New land	Cumulative area	Capital	Recurrent	Total	High Prices	Low Prices	High Prices	Low Prices
1995	586	586	923	28	951	-	-	(951)	(951)
1996	586	1 172	923	83	1 006	1 017	832	11	(174)
1997	586	1 758	923	138	1 061	3 050	2 495	1 989	1 434
1998	586	2 344	923	193	1 116	5 591	4 573	4 475	3 457
1999	586	2 930	923	248	1 171	8 132	6 651	6 961	5 480
2000	-	2 930	-	275	275	10 673	8 729	10 398	8 454
2001	-	2 930	-	275	275	12 198	9 977	11 923	9 702
2002 to 2035	-	2 930	-	275	275	12 707	10 393	12 432	10 118

Net present values at year 0 (1994):

Discount rate	High Prices	Low Prices
5%	169 258	136 954
10%	81 304	65 473
15%	46 375	37 127
Internal rates of return	151%	128%

These costs are very low compared with those of large government projects or even the private banana farms. This is because these schemes are small and easy to develop, the main cost being the pumpset itself. They are usually located near the river and normally involve little more than a pumpset and the construction of a simple network of earthen irrigation channels by hand.

(b) Recurrent Costs

With an eight year diesel pumpset life, and spares and maintenance costs being the same as depreciation, annual pumpset costs excluding fuel would be as follows:

Financial cost	SoSh 36 000
FE cost (80%)	US$ 320
Economic cost (FE shadow priced)	SoSh 50 400

With the assumed cropping pattern the average annual irrigation water requirements and pumpage for a 5 ha scheme would be 108 800 m^3 as shown in Table 7.5.

TABLE 7.5

Average Annual Irrigation Pumpage for a 5 ha Private Pump Scheme

Crop	Area (ha)	Net crop requirement per ha (m^3)	Total requirement (m^3)
Rice	0.5	14 280	7 140
Maize	4.5	3 500(1)	15 750
Sesame	3.5	3 300(1)	11 550
Pulses	1.0	3 300(1)	3 300
Vegetables	1.75	3 300(1)	5 775
Total			43 515
Requirement at pump station, assuming 40% overall irrigation efficiency			108 800

Note: (1) Approximate estimates based on Homboy Project calculations.

With a pumping output of 148.2 m^3/l of diesel fuel (see Section 6.5) total diesel consumption would be 734 l per annum. With an addition of 10% for lubricants, the annual costs would be:

Economic cost, at SoSh 59/l + 10%	SoSh 47 600
Direct FE cost, at US$ 0.38/l + 10%	US$ 307

A sum of SoSh 1 100/ha, equivalent to 10 man days of labour, has also been included in order to cover general scheme maintenance. Total annual recurrent costs for a 5 ha scheme would then be:

	Economic cost	Direct FE cost (US$)
Pumpset maintenance and depreciation	50 400	320
Fuel and lubricants	47 600	307
Scheme maintenance	5 500	-
Total	103 500	627
Per hectare	20 700	125

Costs are assumed to be only 50% of the full level in the first year of development.

7.3.3 Benefits

Table 7.6 shows the benefits from a 5 ha scheme at full production. Since such schemes can be developed very rapidly, the assumption made is that the build-up in benefits would be correspondingly rapid, the benefits being 25% of the full level in the first year of development, 75% in the second year and 100% from the third year onwards.

7.3.4 Total Benefits and Costs from the Expansion of Other Private Pump Irrigation

Table 7.7 shows the total year-by-year economic benefits and costs for the expansion of small-scale private pump irrigation due to Bardheere. Total annual net benefits would be very high, reaching SoSh 1 049 million and SoSh 789 million at High and Low prices respectively by the year 2007. At a 10% discount rate the present value of net benefits as at 1994 would be SoSh 5 672 million and SoSh 4 188 million respectively. These very attractive returns are due primarily to the low capital and recurrent costs of this type of small-scale private pump irrigation.

Direct foreign exchange benefits per year from the expansion of this form of irrigation (Table 7.8) would also be high, reaching US$ 4.8 million and US$ 3.6 million at High and Low prices respectively by the year 2 007. At a 10% discount rate the respective net present values as at 1994 would be US$ 25.8 million and US$ 18.8 million.

7.4 Juba Sugar Project Phase II

7.4.1 JSP II Capital Costs

(a) JSP II Sugar Factory

Capacity at the existing JSP sugar factory is 70 000 tonnes of sugar per annum. This would be fully utilised by JSPI when production reaches its full level after Bardheere is built. JSP II would thus need a new factory, which could be

TABLE 7.6

Annual Benefits from a 5 ha Private Pump Scheme at Full Production (at 1987 Constant Prices)

Crop	Area (ha)	Economic returns (SoSh '000)		Direct FE returns (US$)	
		High Prices	Low Prices	High Prices	Low Prices
Rice:	0.5				
Returns/ha(1)		56.8	28.4	599	374
Total		28.4	14.2	299	187
Maize:	4.5				
Returns/ha(1)		42.4	33.0	368	295
Total		190.8	148.5	1 656	1 327
Sesame:	3.5				
Returns/ha(1)		41.9	32.5	339	279
Total		146.6	113.7	1 186	976
Pulses:	1.0				
Returns/ha(1)		24.6	19.1	226	184
Total		24.6	19.1	226	184
Vegetables	1.75				
Returns/ha(1)		176.6	146.6	-	-
Total		309.0	256.6	-	-
Total		699.4	552.1	3 367	2 674
Per hectare		139.9	110.4	673	535

Notes: (1) See Table 4.2.

TABLE 7.7

Annual Economic Benefits and Costs from the Expansion of Small-Scale Private Irrigation
(SoSh million at 1987 constant prices)

Year	Irrigated area (ha) New land	Irrigated area (ha) Cumulative area	Costs Capital	Costs Recurrent	Costs Total	Benefits High Prices	Benefits Low Prices	Net cash flow High Prices	Net cash flow Low Prices
1995	800	800	42.1	8.3	50.4	28.0	22.1	(22.4)	(28.3)
1996	800	1 600	42.1	24.8	66.9	111.9	88.3	45.0	21.4
1997	800	2 400	42.1	41.4	83.5	223.8	176.6	140.3	93.1
1998	800	3 200	42.1	58.0	100.1	335.8	265.0	235.7	164.9
1999	800	4 000	42.1	74.5	116.6	447.7	353.3	331.1	236.7
2000	800	4 800	42.1	91.1	133.2	559.6	441.6	426.4	308.4
2001	800	5 600	42.1	107.7	149.8	671.5	529.9	521.7	380.1
2002	800	6 400	42.1	124.2	166.3	783.4	618.2	617.1	451.9
2003	800	7 200	42.1	140.8	182.9	895.4	706.6	712.5	523.7
2004	800	8 000	42.1	157.3	199.4	1 007.3	794.9	807.9	595.5
2005	800	8 800	42.1	173.9	216.0	1 119.2	883.2	903.2	667.2
2006	-	8 800	-	182.2	182.2	1 203.1	949.4	1 020.9	767.2
2007 to 2035	-	8 800		182.2	182.2	1 231.1	971.5	1 048.9	789.3

Net present values at year 0 (1994):

Discount rate	Net cash flow High Prices	Net cash flow Low Prices
5%	12 596	9 375
10%	5 672	4 188
15%	3 060	2 238
Internal rates of return	330%	201%

TABLE 7.8

Annual Direct Foreign Exchange Benefits and Costs from the Expansion of Small-Scale Private Irrigation (US$ '000 at 1987 constant prices)

Year	Irrigated area (ha) New land	Irrigated area (ha) Cumulative area	FE costs Capital	FE costs Recurrent	FE costs Total	FE benefits High Prices	FE benefits Low Prices	Net cash flow High Prices	Net cash flow Low Prices
1995	800	800	226	50	276	135	107	(141)	(169)
1996	800	1 600	226	150	376	538	428	162	52
1997	800	2 400	226	250	476	1 077	856	601	380
1998	800	3 200	226	350	576	1 615	1 284	1 039	708
1999	800	4 000	226	450	676	2 154	1 712	1 478	1 036
2000	800	4 800	226	550	776	2 692	2 140	1 916	1 364
2001	800	5 600	226	650	876	3 230	2 568	2 354	1 692
2002	800	6 400	226	750	976	3 768	2 996	2 792	2 020
2003	800	7 200	226	850	1 076	4 307	3 424	3 231	2 348
2004	800	8 000	226	950	1 176	4 845	3 852	3 669	2 676
2005	800	8 800	226	1 050	1 276	5 384	4 280	4 108	3 004
2006	-	8 800	-	1 100	1 100	5 787	4 601	4 687	3 501
2007 to 2035		8 800		1 100	1 100	5 922	4 708	4 822	3 608

Net present values at year 0 (1994):

Discount rate	Net cash flow High Prices	Net cash flow Low Prices
5%	57 539	42 478
10%	25 790	18 850
15%	13 838	9 995
Internal rates of return	243%	156%

either an extension to the existing unit, but operating independently to a considerable degree, or on a completely new site. For costing purposes the former alternative has been adopted.

The JSP I factory cost US$ 62 million and was built in the late 1970s. On the basis of an inflation rate of 3% per annum between the late 1970s and 1987 (according to IBRD's MUV Index, it has, in fact, been slightly below this) and taking the JSP I factory construction period mid point as being 1978, the cost in 1987 prices would be $81 million. As an expansion of an existing site the costs for JSP II might be somewhat less, but on the other hand, inflation of sugar factory costs could well have been higher than 3% per annum. To estimate JSP II factory capital costs, therefore, we have taken the US$ 81 million figure and multiplied it by the ratio between JSP I and JSP II factory capacities (70 000 t/annum and 63 000 t/annum) to arrive at a capital cost of US$ 73 million. The JSP II capacity is based on the sugar yield of 10.0 t/ha estimated for JSP I with Bardheere.

(b) Other JSP II Capital Costs

Excluding the factory, JSP I is assumed to have cost about US$ 144 million ($19 550/ha at current prices) after allowing for the US$ 5 million of proposed additional expenditure on drainage, roads and other facilities. JSP II could be expected to be somewhat cheaper, because of the use that JSP II would make of JSP I's existing infrastructure and services (e.g. headquarters offices and workshops). Costing of JSP II has been based on experience from JSP I and Mogambo Phase I and on the cost estimates made for the Homboy study. As shown in Table 7.9, total capital costs are estimated to be US$ 188.2 million (US$ 29 870/ha), of which US$ 133.6 million (71%) would be foreign exchange.

With FE shadow pricing the economic cost would be SoSh 22 951 million. Based on the programme shown in Table 3.5, this expenditure is assumed to be incurred over a six year period from 1993 to 1998, cane and sugar production beginning in 1995, the third year of development, and reaching its full level in the year 2000.

7.4.2 JSP II Recurrent Costs

Recurrent costs of cane production, harvesting and transport are covered in the crop budget presented in Table A.18 of Appendix A. Other recurrent costs would include:

- factory operating costs
- electricity for irrigation and drainage pumping
- irrigation and drainage pumpset maintenance and depreciation
- other sprinkler irrigation costs
- scheme administration, management and maintenance

(a) Factory Operating Costs

In Section 6.1.2 JSP I factory operating costs excluding depreciation were estimated to be US$ 80/tonne of sugar, of which US$ 32/t was directly variable with the level of sugar output. As a rough approximation a further US$ 20/t has

TABLE 7.9

JSP II Capital Costs (US$ million at 1987 Prices)

Item	Total cost (US$)	FE[1] per cent	FE cost (US$)
Non-Sugar Factory Costs			
Buildings, services and roads	15.1	60	9.1
Sampling, testing and operation	0.9	70	0.6
Bush clearance, level survey and land planing	8.8	70	6.2
Canal and drain earthworks	8.8	70	6.2
Canal and drain structures	4.7	70	3.3
Sprinkler irrigation system	53.0	80	42.4
Drainage pump stations	0.9	75	0.7
Vehicles and machinery	3.8	85	3.2
Engineering design and supervision (10%)	9.6	80	7.7
Contingencies (10%)	9.6		7.2
Sub-total	115.2	68	78.9
Sugar factory	73.0	75	54.7
TOTAL	188.2	71	133.6
Cost per hectare	US$ 29 870		

Note: (1) These represent the assumed actual direct FE expenditure rather than the FE percentages demanded by contractors. Contractors often require FE percentages approaching 100% but then use part of the sum on local expenditure (labour, materials, etc.).

been added to cover depreciation (i.e. replacement) of plant and equipment, but not the factory itself, which is assumed to last for the whole 40 years of the project life). At a projected sugar yield of 9.98 t per cane hectare (Section 6.11.2), total sugar output would be 62 874 tonnes. Factory costs would thus be US $ 6.29 million. With an overall FE content of 75% the economic cost would be SoSh 778 million per year.

(b) Electricity for Irrigation and Drainage Pumping

For JSP I total pumping electricity consumption with Bardheere for sprinkler irrigation and drainage was estimated to be 35.771 million kWh (Section 6.1.4), costing SoSh 214.5 million per year at economic prices. Based on the JSP II irrigated area of 6 300 ha, as compared with 7 365 ha on JSP I, the electricity cost for JSP II would be SoSh 183 million.

(c) Pumpset Maintenance and Depreciation

The total JSP I capital costs of electric sprinkler and drainage pumpsets was estimated to be US$ 1 040 000 and US$ 426 000 respectively, the total being US$ 1 466 000. Annual maintenance and depreciation would be 10% of this, or US$ 147 000. With an 80% FE content the FE cost would be US$ 118 000 and the economic cost would be SoSh 15 million. With the JSP II irrigated area being 85.5% of the JSP I area, the comparable figures for JSP II would be an FE cost of US$ 101 000 and an economic cost of SoSh 13 million.

(d) Other Sprinkler Irrigation Costs

Of the US$ 53.0 million capital cost for the sprinker irrigation system (see Table 7.9) US$ 34.3 million (65%) would be for the buried mains and distribution system. Maintenance costs for this system would be low and replacement very infrequent. Taking 1% of the capital cost to cover such expenditure, annual costs would be US$ 343 000. A further US$ 12.4 million of the capital investment would be for the sprinkler equipment, for which maintenance and depreciation costs would be much higher. Allowing 10% per annum for each, recurrent expenditure on the sprinkler equipment would be US$ 2 480 000 per annum. The overall FE content of these costs is assumed to be 75%, in which case the total FE costs would be US$ 2 823 000 and the economic cost would be SoSh 349 million.

(e) Scheme Administration, Management and Maintenance

These costs include staff and labour, scheme maintenance, administration and other overheads. Budgetted expenditure for such items in the JSP 1987 budget are as follows, based on the exchange rate of SoSh 100 per US$ 1 assumed in the budget and the total JSP I area of 7 365 ha:

	US$/ha per annum
Administration	599
Area upkeep (presumably this covers all general scheme maintenance)	158
Various Agricultural Department Overheads (Agric. Admin., Agronomy, Agric. Manager's Overhead, and Planting Section)	43
Total	800

Source: JSP 1987 Budget, Tables 10 and 13.

Costs per hectare could be expected to be lower in JSP II, because it would be an extension to the existing JSP I and would share some of its staff and facilities. Area upkeep costs would probably not be much reduced, but administrative costs per hectare should be significantly lower. Based on discussions with BAI, they have been taken to be 60% of JSP I costs, or US$ 480/ha, of which 60% would be FE. Total JSP II costs would thus be US$ 3 024 000, FE costs would be US$ 1 814 000 and economic costs would be SoSh 354 million.

(f) Total Recurrent Costs

Table 7.10 shows the annual recurrent costs for JSP II at full production, excluding cane production, harvesting and transport. Economic costs would be SoSh 1 677 million and direct FE costs US$ 11.03 million per year.

TABLE 7.10

JSP II Annual Recurrent Costs, Excluding Cane Production, Harvesting and Transport (at 1987 Constant Prices)

Item	Economic cost (SoSh million)	Direct FE cost (US$ '000)
Factory operating costs	778	6 290
Pumping electricity	183	-
Pumpset maintenance and depreciation	13	101
Other sprinkler irrigation costs	349	2 823
Scheme administration, management and maintenance	354	1 814
Total	1 677	11 028

7.4.3 JSP II Benefits

(a) Gross Output

At full production JSP II would produce 62 874 tonnes of sugar per year, worth SoSh 3 659 million at the economic price of SoSh 58 200/t (Table 6.2) and US$ 25.53 million in terms of direct FE savings (based on the FE value of US$ 406/t given in Table 6.2).

(b) Costs of Cane Production, Harvesting and Transport

Assuming 3.5 ratoon crops per plant crop (the assumed JSP I average), the costs per total hectare of cane (6 300 ha) calculated in Table A.18 are SoSh 136 200 at economic prices and US$ 704 in direct FE. Total JSP II costs would then be SoSh 858 million at economic prices and US$ 4.44 million in direct FE.

(c) Net Returns

Based on the above figures, net returns per year would be SoSh 2 801 million at economic prices and US$ 21.09 million in direct FE.

7.4.4 Total JSP II Benefits and Costs

Table 7.11 shows the estimated year-by-year benefits and costs for JSP II. Economic returns from the project would be low, with an internal rate of return of only 2.9% at economic prices and 5.6% in terms of direct FE. This is a result mainly of the high capital and recurrent costs of such projects. Even with the comparatively high cane and sugar yields attainable on JSP, the recurrent costs would be equivalent to 50 to 60% of annual benefits at full production, leaving a correspondingly reduced sum to meet the capital costs.

A major reason for JSP II low returns is the very high costs associated with sprinkler irrigation. Sprinkler irrigation is expensive in terms of both capital costs (US$ 8 400/ha excluding contingencies and engineering and supervision) and recurrent costs. Maintenance and replacement expenditure on the sprinkler equipment would be particularly heavy, because of its vulnerability to damage and its comparatively short working life. If JSP II would be developed using surface rather than sprinkler irrigation its returns would be substantially improved. The difficulty, however, would be to find a large enough contiguous area of suitable land.

7.5 Homboy Project

The economic returns from Homboy Project are detailed in Annex I. Internal rates of return (IRRs), were calculated to be as follows:

	High Prices (%)	Low Prices (%)
Main analysis	18.8	14.7.
Returns if bananas are excluded from the project	11.6	8.4

At a 10% discount rate net present values (NPVs) as at 1992 for the main analysis were US$ 54.90 million (SoSh 4 941 million) at High Prices and US$ 27.33 million (SoSh 2 459 million) at Low Prices. Taking 1994 rather than 1992 as Year 0, the respective NPVs would be SoSh 5 979 million and SoSh 2 975 million.

TABLE 7.11

Economic Benefits and Costs from Juba Sugar Project Phase II
(at 1987 constant prices)

Year	Irrigated area (ha)		Economic prices (SoSh million)				Direct FE (US$ million)			
	New land	Cumulative area	Capital costs	Recurrent costs	Benefits	Net cash flow	Capital costs	Recurrent costs	Benefits	Net cash flow
1993	-	-	3 443	-	-	(3 443)	20.04	-	-	(20.04)
1994	-	-	4 590	168	-	(4 758)	26.72	1.10	-	(27.82)
1995	1 000	1 000	4 590	419	140	(4 869)	26.72	2.76	1.05	(28.43)
1996	1 500	2 500	4 590	838	700	(4 728)	26.72	5.51	5.27	(26.96)
1997	1 500	4 000	4 590	1 174	1 260	(4 504)	26.72	7.72	9.49	(24.95)
1998	1 500	5 500	1 148	1 509	1 821	(836)	6.68	9.93	13.71	(2.90)
1999	800	6 300	-	1 677	2 381	704	-	11.03	17.93	6.90
2000 to 2035	-	6 300	-	1 677	2 801	1 124	-	11.03	21.09	10.06
Net present values at year 0 (1994)(1):										
Discount rate										
5%						-6 759				-11.47
10%						-13 644				-54.0
15%						-15 909				-77.45
Internal rates of return						2.9%				5.6%

Note: (1) 1994 has been taken as Year 0, to maintain uniformity with the other economic analyses. The net cash flows have been discounted back to 1992 and then compounded forward to 1994.

Homboy Project thus gives attractive returns and could make a significant contribution towards meeting the costs of Bardheere dam. It should be noted, however, that these high returns are dependent on the successful introduction of smallholder banana production on one third of the project area. Export banana production by smallholders has not been tried on a commercial scale before in Somalia. If it proved to be unsuccessful, and bananas were not grown in the project, returns would be greatly reduced, the IRRs falling to 11.6% at High Prices and 8.4% at Low Prices.

7.6 Mogambo IIB Project

7.6.1 General

Mogambo IIB would have an irrigated area of 1 886 ha, say 1 900 ha, all under sprinkler irrigation. Cropping is assumed to be based on a Homboy type of general arable rotation with 200% annual intensity, with 60% maize, 48% cotton, 48% sesame, 36% cowpeas and 8% vegetables. Total irrigation requirements at the pump station would be 13 000 m^3/ha or 24.7 million m^3. No land levelling, flood protection or extra drainage pumping equipment would be required, but an extra 2.2 m^3/s of pumping capacity would be installed at the existing river pump station. Little expenditure on canals would be necessary because the sprinkler systems would pump directly from the existing Phase I canals or from short spurs leading off them.

7.6.2 Mogambo IIB Capital Costs

Costing has been based particularly on the actual costs recorded on the existing Mogambo project. As shown in Table 7.12, total capital costs are estimated to be US$ 30.35 million (US$ 15 970/ha), of which US$ 23.09 million (76%) would be FE. At US$ 15 970, costs per hectare would be substantially greater than for Homboy and also for many new surface irrigated projects, because of the very high costs of the sprinkler irrigation system, at about US$ 8 400/ha.

With FE shadow pricing the economic cost would be SoSh 3 769 million. As an extension to an existing scheme, with few major civil works (e.g. pump stations or main canals) required, Mogambo IIB could be developed fairly rapidly; a two year construction period has therefore been assumed.

7.6.3 Mogambo II B Recurrent Costs

(a) Electricity for Irrigation and Drainage Pumping

At 11 720 m^3/ha annual consumption at the sprinkler pump station the total spinkler pumpage would be 22.27 million m^3 (MCM). Taking the same sprinkler irrigation output as for Mogambo IA, 3.7 m^3/kWh, annual electrical consumption would be 6.019 million kWh.

With an output of 43.9 m^3/kWh (see Section 6.3.3), annual consumption for river pumping would be 0.563 million kWh. Taking the Mogambo I and IIA drainage pumping energy consumption of 122 kWh/ha, drainage pumping for Mogambo IIB would use 0.232 million kWh per year.

Total pumping energy consumption for Mogambo IIB would thus be 6.814 million kWh and the annual cost would be SoSh 40.9 million.

TABLE 7.12

Mogambo IIB Capital Costs (US$ '000 at 1987 Constant Prices)

Item	Total cost (US$)	FE (per cent)	FE cost (US$)
Buildings, services and roads	3 790	60	2 274
Sampling, testing and operation	268	70	188
Bush clearance, level survey and land planing	2 656	70	1 859
Earthworks	289	70	202
Drain structures	555	70	388
Water control equipment	275	80	219
Irrigation pumping equipment and installation	369	80	295
Sprinkler irrigation system	15 985	80	12 788
Vehicles and equipment (excluding farm machinery)	1 106	85	940
Engineering design and supervision (10%)	2 529	80	2 023
Contingencies (10%)	2 529		1 915
Total	30 350	76	23 091
Cost per hectare	15 970		

(b) Pumpset Maintenance and Depreciation

Capital costs of the additional river pumping equipment needed for Mogambo IIB would be US$ 369 000, in which case annual maintenance and depreciation would be US$ 36 900, of which 80% (US$ 29 500) would be FE. Annual economic costs would thus be SoSh 4.6 million.

The JSP II sprinkler and drainage pumpset maintenance and depreciation cost would be SoSh 2 060/ha at economic prices and US$ 16.0/ha in direct FE (Section 7.4.2). Applying the same figures to Mogambo IIB, total annual costs would be SoSh 3.9 million and US$ 30 400 in direct FE.

(c) Other Sprinkler Irrigation Costs

Taking the JSP II figure for maintenance and replacement expenditure on sprinkler irrigation systems (SoSh 55 400/ha economic costs and US$ 448/ha in direct FE), the comparable costs for Mogambo IIB would be SoSh 105 million economic costs and US$ 851 200 in direct FE.

(d) Other Costs

Scheme maintenance costs have been taken to be 2% of the capital costs of buildings, services and roads, earthworks, drain structures and water control equipment, or US$ 98 200, of which the FE cost would be 65% (US$ 63 800). The economic cost would thus be SoSh 7.6 million per year.

Operation, maintenance and replacement costs of vehicles and equipment, excluding agricultural machinery, have been taken as 30% of the capital costs, or US$ 331 800, with an FE cost of US$ 232 300 (70%). The annual economic cost would thus be SoSh 40.3 million.

Staff and labour costs, excluding expatriate technical assistance, are estimated to be SoSh 18 million at both economic and financial prices, with no direct FE cost. An allowance of US$ 100 000 per year (FE cost US$ 75 000) has been made for expatriate technical assistance for the first three years of scheme operation, the economic cost being SoSh 12.4 million per year.

(e) Total Recurrent Costs

Table 7.13 shows the total recurrent costs of Mogambo IIB at full development, excluding crop production costs. Costs would be high, at SoSh 115 900/ha and US$ 635/ha in direct FE, largely because of the heavy costs of sprinkler irrigation operation, maintenance and replacement.

7.6.4 Mogambo IIB Benefits

Table 7.14 shows the calculation of Mogambo IIB benefits at full production, based on the cropping pattern outlined in Section 7.5.1 and the net returns per hectare given in Table 4.2.

TABLE 7.13

Mogambo IIB Annual Recurrent Costs, Excluding Crop Production Costs (at 1987 constant prices)

Item	Economic cost (SoSh million)	Direct FE cost (US$ 000)
Pumping electricity	40.9	-
Pumpset maintenance and depreciation	8.5	59.9
Other sprinkler irrigation costs	105.0	851.2
Scheme maintenance	7.6	63.8
Vehicle and equipment operation, maintenance and replacement	40.3	232.3
Staff and labour	18.0	-
Total	SoSh 220.3	US$1 207.2
Cost per hectare	115 900	635
Annual cost of expatriate technical assistance in first 3 years of operation	12.4	75.0

TABLE 7.14

Mogambo IIB Economic and Direct Foreign Exchange Benefits (at 1987 Constant Prices)

	Economic returns (SoSh '000)		Direct FE returns (US$)	
	High Prices	Low Prices	High Prices	Low Prices
Net returns/ha				
Maize	53.0	40.5	463	365
Cotton	81.9	78.1	779	751
Sesame	52.8	42.2	409	328
Cowpeas	34.3	25.8	310	245
Vegetables	252.0	210.1	-	-
Total net returns				
Maize (1 140 ha)	60.4	46.2	528	416
Cotton (912 ha)	74.7	71.2	710	685
Sesame (912 ha)	48.2	38.5	373	299
Cowpeas (684 ha)	23.5	17.6	212	168
Vegetables (152 ha)	38.3	31.9	-	-
Total	245.1	205.4	1 823	1 568

7.6.5 The Economic Viability of Mogambo IIB

Comparison of the annual recurrent costs (Table 7.13) with the annual benefits (Table 7.14) shows that Mogambo IIB would not be economically viable. At High Prices its economic benefits (SoSh 245 million) would be only SoSh 25 million (11%) higher than its recurrent costs (SoSh 220 million), leaving little surplus to meet the capital expenditure. Given this situation, the internal rate of return over the 40 year analysis period applied for all the Bardheere economic analyses would be negative. At Low Prices the results would be considerably worse, since the annual benefits would not cover even the annual costs, the deficit being SoSh 15 million per annum. Clearly, development of Mogambo IIB cannot be justified on economic grounds. The main reason is that the area is not suitable for surface irrigation, so sprinkler irrigation would be required, with its attendant high capital and recurrent costs.

7.7 Unidentified New Government Projects

7.7.1 General

Approximate costings have been prepared for typical new large government irrigation projects (over 1 000 ha) probably located upstream of Jilib on slightly undulating topography similar to that at Mogambo and a fairly dense bush and tree cover, like Mogambo. Surface irrigation would be used, water being pumped from the river Juba by electric pumps. Soils would be the heterogeneous alluval sediments of the type found at Mogambo and Homboy. These are suitable for a wide range of crops, and costings have been based on two alternative farming systems, double cropping of paddy rice and double cropping of other crops (the Homboy Mixed Arable Cropping System). Flood protection would not be required, because Bardheere dam would have eliminated major flood problems, but pumped drainage would be necessary. The project area has been taken to be 3 000 ha.

7.7.2 Capital Costs

The main capital costs have been estimated largely on the basis of past experience with Mogambo and the provision of a reasonably high standard of infrastructure and services. In the economic analysis an alternative capital cost scenario has, however, also been evaluated, in which the costs would be very much lower, of the order envisaged for Homboy. For this scenario the capital costs have been taken to be half those assumed for the main analysis, but with the recurrent costs being the same as for the main scenario.

Table 7.15 shows the assumed capital costs for the main scenario, for a 3 000 ha project. Costs are estimated to be US$ 31.36 million (US$ 10 450/ha), of which US$ 21.97 million (70%) would be FE. Total economic costs would be SoSh 3 810 million. Since the difference in capital costs between the rice and mixed cropping system would be small this figure has been applied for both.

7.7.3 Recurrent Costs

(a) Electricity for Irrigation and Drainage Pumping

Drainage pumping energy use per hectare would be the same as for Mogambo, 122 kWh/ha per year, so total annual consumption would be 0.366 million kWh.

TABLE 7.15

Capital Costs for a Typical 3 000 hectare Government Irrigation Project (US$ 000 at Constant 1987 Prices)

Item	Cost per hectare (US$)	Total cost	FE (%)	FE cost
Buildings, services and roads	2 000	6 000	60	3 600
Sampling, testing and operation	140	420	70	294
Bush clearance, level survey and land planing	2 500	7 500	70	5 250
Irrigation and drainage system	2 700	8 100	70	5 670
Irrigation pump stations	500(1)	1 500	75	1 125
Drainage pump stations	290	870	75	652
Vehicles and equipment	580	1 740	85	1 479
Engineering design and supervision (10%)		2 613	80	2 090
Contingencies (10%)		2 613		1 807
Total		31 356	70	21 967
Cost per hectare		US$10 450		US$7 320

Note: (1) This is for double-cropped rice. It would be about US$ 200 per hectare less for mixed cropping.

Full rice double cropping would require 33 350 m^3/ha at the river pump station, the annual total thus being 100.0 MCM. At 43.9 m^3/kWh, total electricity consumed would be 2.278 million kWh. Mixed double cropping would need 20 550 m^3/ha, the annual total being 61.6 MCM and annual electricity consumption being 1.403 million kWh.

At SoSh 6/kWh, annual pumping electricity costs would be:

	SoSh million
Rice double cropping	15.9
Mixed double cropping	10.6

(b) Pumpset Maintenance and Depreciation

Based on the Mogambo I and IIA figures (Section 6.3.2), the capital costs of drainage pumpsets would be US$ 63/ha. At 10%, annual maintenance and depreciation would cost US$ 6.3/ha, or US$ 18 900 for a 3 000 ha project, of which 80% (US$ 15 120) would be FE. The economic cost would be SoSh 2.4 million.

For rice double cropping the capital cost of electric pumpsets for irrigation supply would be US$ 516 000, whereas for mixed cropping it would be US$ 336 000. Maintenance and depreciation costs would be US$ 51 600 and US$ 33 600 respectively, of which US$ 41 300 (80%) and US$ 26 900 would be FE. Economic costs would thus be SoSh 6.5 million and SoSh 4.2 million. Total annual pumpset maintenance and depreciation costs would then be SoSh 8.9 million for rice cropping and SoSh 6.6 million for mixed cropping.

(c) Other Costs

Scheme maintenance has been taken as 2% of the capital cost of buildings, services and roads, the irrigation and drainage system and the irrigation and drainage system, the total annual cost thus being US$ 329 400 and the FE cost being US$ 214 100 (65%). The economic cost would thus be SoSh 39.3 million.

Operation, maintenance and replacement costs of vehicles and equipment, and staff and labour costs have been calculated by applying the per hectare costs derived for Mogambo IIB (Table 7.13). On this basis the economic cost for a 3 000 ha project would be SoSh 92.1 million per year and the direct FE cost would be US$ 366 800.

Being a new project, more expatriate technical assistance is likely to be needed than for Mogambo IIB and for a longer period. An allowance of US$ 250 000 per year (FE cost US$ 187 500) for the first five years of operation has therefore been made.

(d) Total Recurrent Costs

Table 7.16 shows the total recurrent expenditure for a 3 000 ha project at full development, excluding crop production costs. Economic costs would be SoSh 49 500 to 52 100/ha, less than half those for Mogambo IIB. Since the costs for the rice and mixed cropping systems are so similar the same figure, the average of the two costs, has been used for the economic analyses.

7.7.4 Benefits

Table 7.17 summarises the annual benefits from a 3 000 ha project at full production.

7.7.5 Total benefits and Costs from a 3 000 ha Project

Tables 7.18 to 7.21 show the year-by-year benefits and costs for a 3 000 ha project for the two cropping patterns, two crop price scenarios and 'high' capital costs. Construction is assumed to take four years, starting in 1998, and full benefits would be reached in 2005. Internal rates of return (IRRs) at economic prices would be as follows:

	Internal rates of return (%)
High Prices:	
- Rice cropping	4.8
- Mixed cropping	3.6
Low Prices:	
- Rice cropping	-4.5
- Mixed cropping	1.7

Returns from investment in new government irrigation projects thus do not appear to be attractive, even with intensive cropping and High crop prices. One reason is that the recurrent expenditure needed to operate and maintain such schemes is high. Even in the most favourable situation, rice cropping with High Prices (Table 7.18), recurrent costs at full development are equivalent to over one third of the annual economic benefits. Foreign exchange returns are, however, better than the economic returns, with IRRs ranging from 6.1% to 12.9%.

If capital costs were only half the level assumed for the main analysis, being similar to the per hectare costs envisaged for Homboy, IRRs would be substantially higher, as follows:

	IRR (%)
High Prices:	
- Rice cropping	9.8
- Mixed cropping	8.2
Low Prices:	
- Rice cropping	-2.0
- Mixed cropping	5.7 .

Even with these low capital costs, however, this type of new project would be marginal in economic terms. Moreover, the low costs imply a lower standard of scheme infrastructure and services, which may well make the scheme more difficult to operate and manage effectively and may thus result in a reduced level of crop output and economic benefits.

TABLE 7.16

Annual Recurrent Costs of a 3 000 ha Project, Excluding Crop Production Costs

Item	Rice cropping Economic cost (SoSh million)	Rice cropping FE cost (US$ '000)	Mixed cropping Economic cost (SoSh million)	Mixed cropping FE cost (US$ '000)
Pumping electricity	15.9	-	10.6	
Pumpset maintenance and depreciation	8.9	56	6.6	42
Scheme maintenance	39.3	214	39.3	214
Staff, labour, vehicles and equipment	92.1	337	92.1	337
Total	156.2	607	148.6	593
Cost per ha	SoSh 52 100	US$202	SoSh 49 500	US$198
Annual cost of expatriate TA for 5 years	30.9	187	30.9	187

TABLE 7.17

Annual Benefits from a 3 000 ha Project (at 1987 constant prices)

	Economic returns (SoSh million)		FE returns (US$ 000)	
	High Prices	Low Prices	High Prices	Low Prices
1. Rice Double Cropping				
Returns per crop ha (SoSh'000)	71.8	33.6	732	431
Total returns from 6 000 ha of rice	430.8	201.6	4 392	2 586
2. Mixed cropping				
Returns per ha of land, as for Mogambo IIB (Table 7.14) (SoSh '000)	129.0	108.1	959	825
Total returns on 3 000 ha	387.0	324.3	2 877	2 475

TABLE 7.18

Economic Benefits and Costs from a 3 000 ha Project With Rice Cropping at High Prices and 'High' Capital Costs (at 1987 constant prices)

Year	Economic prices (SoSh million) Capital costs	Recurrent costs	Benefits	Net cash flow	Direct FE (US$ '000) Capital costs	Recurrent costs	Benefits	Net cash flow
1998	952.0	-	-	(952.0)	5 492	-	-	(5 492)
1999	953.0	-	-	(953.0)	5 493	-	-	(5 493)
2000	953.0	91.6	43.1	(1 001.5)	5 493	393	439	(4 661)
2001	953.0	183.3	129.2	(1 006.1)	5 492	787	1 318	(4 961)
2002	-	183.3	215.4	32.1	-	787	2 196	1 409
2003	-	183.3	301.6	118.3	-	787	3 074	2 287
2004	-	183.3	387.7	204.4	-	787	3 953	3 166
2005-35	-	152.4	430.8	278.4	-	600	4 392	3 792
Net present values as at 1994(1):								
Discount rate								
5%				-103.7				24 844
10%				-1 162.2				4 367
15%				-1 281.9				-1 691
Internal rates of return:				4.8%				12.9%

Note: (1) 1994 has been taken as the base year (Year 0) for all the Bardheere analyses.

TABLE 7.19

Economic Benefits and Costs from a 3 000 ha Project With Rice Cropping at Low Prices and 'High' Capital Costs (at 1987 constant prices)

Year	Economic prices (SoSh million) Capital costs	Recurrent costs	Benefits	Net cash flow	Direct FE (US$ '000) Capital costs	Recurrent costs	Benefits	Net cash flow
1998	952	-	-	(952.0)	5 492	-	-	(5 492)
1999	953	-	-	(953.0)	5 493	-	-	(5 493)
2000	953	91.6	20.2	(1 116.1)	5 493	393	259	(5 627)
2001	952	183.3	60.5	(1 074.8)	5 492	787	776	(5 503)
2002	-	183.3	100.8	(82.5)	-	787	1 293	506
2003	-	183.3	141.1	(42.2)	-	787	1 810	1 023
2004	-	183.3	181.4	(1.9)	-	787	2 327	1 540
2005-35	-	152.4	201.6	49.2	-	600	2 586	1 986
Net present values as at 1994(1):								
Discount rate								
5%				-2 740.0				4 026
10%				-2 300.5				-4 640
15%				-1 864				-6 305.8
Internal rates of return:				-4.5%				6.5%

Note: (1) 1994 has been taken as the base year (Year 0) for all the Bardheere analyses.

TABLE 7.20

Economic Benefits and Costs from a 3 000 ha Project With Mixed Cropping at High Prices and 'High' Capital Costs (at 1987 constant prices)

Year	Economic prices (SoSh million) Capital costs	Recurrent costs	Benefits	Net cash flow	Direct FE (US$ '000) Capital costs	Recurrent costs	Benefits	Net cash flow
1998	952	-	-	(952.0)	5 492	-	-	(5 492)
1999	953	-	-	(953.0)	5 493	-	-	(5 493)
2000	953	91.6	38.7	(1 005.9)	5 493	393	288	(5 598)
2001	953	183.3	116.1	(1 019.2)	5 492	787	863	(5 416)
2002	-	183.3	193.5	10.2	-	787	1 438	651
2003	-	183.3	270.9	87.6	-	787	2 014	1 227
2004	-	183.3	348.3	165.0	-	787	2 589	1 802
2005-35	-	152.4	387.0	234.6	-	600	2 877	2 277
Net present values as at 1994(1):								
Discount rate								
5%				-594.2		28 761		7 286
10%				-1 369.7		5 813		-3 261
15%				-1 385.4		-2 572		-5 617
Internal rates of return:				3.6%				7.6%

Note: (1) 1994 has been taken as the base year (Year 0) for all the Bardheere analyses.

TABLE 7.21

Economic Benefits and Costs from a 3 000 ha Project With Mixed Cropping at Low Prices and 'High' Capital Costs (at 1987 constant prices)

Year	Economic prices (SoSh million)				Direct FE (US$ '000)			
	Capital costs	Recurrent costs	Benefits	Net cash flow	Capital costs	Recurrent costs	Benefits	Net cash flow
1998	952	-	-	(952.0)	5 492	-	-	(5 492)
1999	953	-	-	(953.0)	5 493	-	-	(5 493)
2000	953	91.6	32.4	(1 012.2)	5 493	393	247	(5 639)
2001	952	183.3	97.3	(1 038.0)	5 492	787	742	(5 537)
2002	-	183.3	162.1	(21.2)	-	787	1 237	450
2003	-	183.3	227.0	43.7	-	787	1 732	945
2004	-	183.3	391.8	108.6	-	787	2 227	1 440
2005-35	-	152.4	324.3	171.9	-	600	2 475	1 875
Net present values as at 1994(1):								
Discount rate								
5%				-1 296.8				2 781
10%				-1 667				-5 168
15%				-1 533.9				-6 569
Internal rates of return:				1.7%				6.1%

Note: (1) 1994 has been taken as the base year (Year 0) for all the Bardheere analyses.

7.8 Overall Bardheere Benefits from New Irrigation

Assuming that only developments which produce IRRs of, say, 7 to 8% or more are considered to produce positive net benefits (i.e. taking 7 to 8% as the breakeven point in terms of economic viability), the main Bardheere benefits from new irrigation would come from the expansion of private banana farms and small-scale private pump irrigation and the Homboy Project. JSP II and Mogambo IIB would not be worth building and other new projects as yet unidentified would be marginal in economic terms.

At a 10% discount rate, the total present value of net benefits from new private sector irrigation and the Homboy Project as at 1994, the year before the dam comes into operation, would be as follows, in SoSh million:

	High Prices	Low Prices
Expansion of private banana farms (Table 7.3	5 288	3 856
Expansion of small-scale private pump irrigation (Table 7.7)	5 672	4 188
Homboy project	5 979	2 975
Total	16 939	11 019

In terms of US dollars, converting from these figures at the official exchange rate of SoSh 90/US$ the respective values would be US$ 188.2 million and US$ 122.4 million. These values are at economic prices and allow for the shadow pricing of foreign exchange. Nevertheless, they are very substantial and would be sufficient to cover a major proportion of the possible dam cost of US$ 300 to 400 million excluding FE shadow pricing. Moreover, 65% to 73% of the benefits would come from private sector development, which, as discussed in Section 7.1, is less vulnerable than public development to institutional and financial constraints.

CHAPTER 8

THE AGRICULTURAL COSTS OF BARDHEERE RESERVOIR FLOODING

8.1 Introduction

As described in Section 3.10, the main agricultural costs from the flooding of the Bardheere reservoir area would be the loss of output from 810 ha of small-scale private pump irrigation and the loss of livestock production.

8.2 Losses of Small-scale Private Pump Irrigation Output

The diesel pumpsets could be removed before the irrigated areas are inundated by the rising waters of the reservoir but the loss of irrigated crop output could not be avoided. Table 8.1 shows the calculation of the value of these losses.

TABLE 8.1

Economic Value of the Loss of Output from 810 ha of Private Pump Irrigation Flooded by Bardheere Reservoir

	Economic returns (SoSh million)		Direct FE returns (US$ '000)	
	High Prices	Low Prices	High Prices	Low Prices
1. Crop net returns:				
- Per hectare (SoSh) (Table 7.6)	139 900	110 400	673	535
- Total net returns from 810 ha	113.4	89.4	545 100	433 300
2. Recurrent Costs of private pump scheme operation and maintenance:				
- Per hectare (SoSh) (Section 7.3.2)	20 700	20 700	125	125
- Total on 810 ha	16.8	16.8	101 200	101 200
3. Net benefit	96.5	72.6	443 900	332 100
4. Present Value at 1994 of net benefits over the 1995-2035 period:				
Discount rate:				
5%	1 669	1 256	7 677	5 744
10%	946	711	4 350	3 254
15%	641	482	2 950	2 207

Losses of pump irrigation output would thus be substantial, the total present value at 1994 at a 10% discount rate being SoSh 946 million at High Prices and SoSh 711 million at Low Prices over the 1995 to 2035 analysis period.

8.3 Loss of Livestock Output

Typical rates of annual offtake from cattle in Somalia under traditional management are 5 to 6% for sale, with perhaps 5 to 6% for consumption, the annual total thus being 10 to 12%. Liveweight at the time of sale or consumption could be taken to be 250 kg, the same as the standard livestock unit. Average cattle prices quoted in November 1986 at Homboy were SoSh 25 to 30/kg liveweight, equivalent to SoSh 6 250 to 7 500 per animal. Taking an average price of SoSh 7 000 and an average offtake of 11%, annual output per 100 cattle would be SoSh 77 000. If the total livestock population in the area to be flooded is 10 240 to 15 360 cattle equivalents the total loss of livestock production would be SoSh 7.9 to 11.8 million, a not very substantial figure. Assuming that much of this production could be exported, through Kismayo, the FE content of this loss could be taken to be 75%, or US$ 87 800 to 131 100, and the economic value would be SoSh 10.9 to 16.2 million. Taking the average of these two values as the loss, the present value at 1994 of the loss over the 1995 to 2035 analysis period would be as follows:

Discount rate (%)	Economic returns (SoSh million)	FE returns (US$ 000)
5	233	1 893
10	132	1 073
15	90	727

8.4 Total Agricultural Losses Due to Reservoir Flooding

Based on the above estimates, total agricultural losses from the Bardheere reservoir flooding would be as shown in Table 8.2.

TABLE 8.2

Total Agricultural Losses from Bardheere Reservoir Flooding

	Economic returns (SoSh million)		Direct FE returns (US$ '000)	
	High Prices	Low Prices	High Prices	Low Prices
1. Losses per annum (from 1995 onwards)				
Private pump irrigation (Table 8.1)	96.5	72.6	443.9	332.1
Livestock (Section8.3)	13.5	13.5	109.4	109.4
Total	110.0	86.1	553.3	441.5
2. Present value of losses over the 1995-2035 period				
Discount rate:				
5%	1 902	1 489	9 570	7 637
10%	1 078	843	5 423	4 327
15%	731	572	3 677	2 934

CHAPTER 9

TOTAL AGRICULTURAL BENEFITS OF THE BARDHEERE DAM PROJECT

9.1 Total BDP Agricultural Benefits

Table 9.1 summarises the estimated net agricultural benefits from Bardheere dam at High and Low economic prices at 1987 constant values. The estimates take account of all the capital and recurrent costs which would be incurred, including the costs of electricity distribution in the main irrigation zones and the losses in agricultural production in the reservoir area.

By the year 2000 annual net benefits would reach SoSh 5 235 million and SoSh 4 310 million at High and Low Prices respectively. By 2010 they would have risen to SoSh 6 686 million and SoSh 5 522 million, the rise being attributable mainly to the progressive increase in flood control benefits due to the growth in population and economic activity in the middle and lower Juba valley and the gradual expansion in the area under small-scale private pump irrigation.

To provide a basis for comparison with the likely capital costs of the Bardheere Dam Project (BDP), the total net present value (NPV) of benefits at a 10% discount rate as at 1994, the year before dam completion, has also been presented. At the High Price scenario, which is considered to be more realistic than the Low Price scenario, being based on actual world market prices in the 1980-85 period, the proportion of total benefits attributable to the three main sources of benefit would be as follows:

Benefit category	Percentage of total NPV before deduction of the costs of reservoir flooding and electrification
Flood control	24
Existing irrigation	35
New irrigation	41
Total	100

The important implication of the above figures is that 60% of the projected benefits would be obtained even if there were no expansion in irrigated areas in the Juba Valley due to the BDP. This indicates that the risks of a serious shortfall in benefits as compared with the projections is much less than with many projects, because they are not dependent on new developments (i.e. new irrigation projects), which may not in fact be implemented, may be delayed or may perform less well than predicted. Moreover, as noted in Section 7.8, two-thirds of the net benefits from new irrigation are expected to come from the private sector (banana farms and small-scale pump irrigation). Experience in Somalia and many other countries suggests that the risks of serious delays or under-performance are less with private sector irrigation development than with the public sector.

TABLE 9.1

Estimated Agricultural Benefits from Bardheere Dam at Economic Prices (SoSh million at 1987 constant prices)

Item	High Prices 2000	High Prices 2010 onwards	Low Prices 2000	Low Prices 2010 onwards
1. Annual net benefits (benefits minus costs)				
(a) Flood control benefits (Table 5.5)	893	1 455	818	1 333
(b) Existing irrigation (Tables 6.11 & 6.12)				
- Juba Sugar Project Phase I	938	938	938	938
- Private banana farms	375	375	319	319
- Others	293	331	185	216
Sub-total	1 606	1 644	1 442	1 473
(c) New irrigation				
- Private banana farms (Table 7.3)	726	883	550	674
- Small-scale private pump irrigation (Table 7.7)	426	1 049	308	789
- Homboy Project (Annex 1)	1 694	1 765	1 278	1 339
Sub-total	2 846	3 697	2 136	2 802
(d) Loss of agricultural output in the Bardheere Reservoir area (Table 8.2)	110	110	86	86
(e) Total net benefits ((a) to (c) minus (d))	5 235	6 686	4 310	5 522
2. Net present value of total net benefits at 1994 at a 10% discount rate				
Flood control benefits (Table 5.5)		10 194		9 336
Existing irrigation (Tables 6.11 & 6.12)		14 763		13 299
New irrigation (Section 7.7)		16 939		11 019
Sub-total		41 896		33 654
Minus:				
- Loss of agricultural output in the reservoir area		1 078		843
- Electrification costs between Jilib and Jamaame (Table 6.16)(1)		843		843
NET TOTAL		39 975		31 968

Note: (1) Assuming, for analysis purposes, that the expenditure on electrification is incurred in 1994, so that electricity becomed available to irrigation and other users by the time the dam comes on stream.

9.2 The Economic Viability of the Bardheere Dam Project

This means, therefore, that the BDP is not dependent for its economic viability on a major programme of new Government irrigation development, which in the past has often been thought to be the case. It can instead go forward as an independent project without a specific irrigation project component. At the same time, however, electricity transmission and distribution in the Juba Valley would have to form an integral part of the BDP, because many of the agricultural benefits are dependent upon the provision of a reliable supply of electricity. Another point is that although the attainment of most of the agricultural benefits does not depend substantially on direct Government action outside the BDP, the increased provision of certain types of public sectors infrastructure and services, such as roads and medium-term credit, would undoubtedly be beneficial. For example, increased provision of medium-term credit would stimulate private irrigation development by providing farmers with the funds needed to buy pumpsets and install irrigation systems.

At this stage it is not clear exactly how much the BDP would cost, but capital costs in the range of US$ 300 to 400 million have been mentioned. If the cost were, say, US$ 350 million at 1987 prices and the foreign exchange (FE) content were, say, 75%, the economic cost at an official exchange of SoSh 90/US$, with FE shadow pricing at 1.5 times this rate, would be SoSh 43 312 million. If this were incurred at an even annual rate over the 1988 to 1994 period, the total capital cost as at 1994 at a 10% discount rate (i.e. compounding the costs forward to a 1994 value) would be SoSh 58 705 million.

At High Prices the net agricultural benefits of SoSh 39 975 million would be sufficient to meet 68% of these capital costs; the comparable percentage at Low Prices would be 54%. Thus the agricultural benefits should be sufficient to meet well over half the costs of the BDP. Excluding the benefits from new irrigation, which are not as certain to be achieved as the other categories, the benefits from flood control and existing irrigation (59% of the total) would meet 40% and 32% of the BDP costs at High and Low Prices respectively. Thus the agricultural benefits would make a very significant contribution to the economic justification of the BDP.

9.3 Other Factors Concerning the Viability of the Bardheere Dam Project

9.3.1 Hydro-electricity Benefits

Apart from agricultural production, the other major benefit of the BDP will be its output of hydro-electricity (HEP). The economic benefits from the provision of a reliable supply of electricity can be considered to be well above the value of the actual kWh produced. The key factor is reliability of supply. At present, the unreliability of supplies from the existing thermal generating stations in Mogadishu and elsewhere, due to fuel shortages, maintenance difficulties and other problems, causes widespread economic and social disruption, the real cost of which is far greater than the financial value of the kWh consumption lost.

9.3.2 Management and Financial Aspects

As noted in Section 3.5, the most critical constraints affecting Somalia's agricultural sector and other sectors of the economy are probably:

(a) The shortage of foreign exchange to meet operation and maintenance expenditure (FE funds to meet capital costs and recurrent costs in the initial years of a project's operation can be more easily obtained, from external donors);

(b) the shortage of Government funds (local currency) to meet operation and maintenance expenditure and

(c) the public sector's limited capacity to implement and operate projects.

On all three counts the BDP has substantial advantages over many alternative investments, such as new Government irrigation projects. In comparison with the magnitude of its economic benefits and electricity output, its operation and maintenance costs in terms of FE and local currency will be relatively low. In their 1985 report on Bardheere Dam Project Hydrology and Optimisation, Electroconsult estimated the recurrent costs for the power component to be about 1% of the capital costs, a typical ratio for large dam projects. By comparison, public irrigation projects like Mogambo, which involve pumping and are complex to manage, especially when smallholder farmers are involved, require heavy annual expenditure.

The BDP's impact on Somalia's FE position is likely to be strongly positive and would therefore relieve pressure on FE resources, to the benefit of the economy as a whole. It will reduce diesel fuel imports substantially and its recurrent FE costs for maintenance and replacement are likely to be below those of the thermal generation plants which it replaces. Although debt service payments in FE to repay the project's capital costs may be substantial, part of the foreign funding for the BDP is likely to be on a grant rather than loan basis and much of the loan finance will probably be on easy interest and repayment terms.

The BDP's impact on Somalia's public finances should also be beneficial, especially in comparison with alternative investments such as irrigation projects. Apart from Bardheere's low running costs, Government will obtain major financial savings from the reduction in thermal plant operation (most of the thermal plants have relatively high operation and maintenance costs) and, of vital importance, a very large annual revenue from the sales of hydro-electricity to consumers. Effective cost recovery is much easier with electricity than with irrigation. Electricity consumers who do not meet their repayment obligations can be easily cut off and are therefore more likely to meet these obligations. In theory a similar policy could be adopted with irrigation, but in practice it rarely is, because of the practical and socio-political problems involved.

In terms of its ease of implementation and management for the Somali Government the BDP need be no more difficult to build and operate than a typical irrigation project. Construction will be carried out mainly by large foreign contractors, with some participation from Somalia private companies, and this would presumably be supervised by suitable consultants.

The project's subsequent operationand maintenance may pose more organisation and management problems, but these need not be unduly difficult to overcome. One possibility would be to organise the project on the same lines as those adopted for Juba Sugar Project. As for JSP, the project organisation could be set up as an independent body which has its own budget, operates on commercial lines (its main income would be the sale of hydro-electricity) and is allowed to set its own salary scales and recruit staff itself. In view of the technical complexity of the dam and power station, external technical assistance would be required, at least in the early years of operation. This could be organised in the same way as with Booker Agriculture International on JSP, the expatriate personnel being members of the management staff, with executive powers, rather than just advisers.

This system appears to have worked well at JSP. Apart from its benefits in terms of the project's technical and financial performance, many Somali staff have been trained and the number of expatriates has been steadily reduced as part of a phased handing-over process.

APPENDIX A

CROP ECONOMIC RETURNS

A1 Introduction

This appendix covers the economic returns for crop yields and situations not already covered in the Homboy study and the direct and foreign exchange (FE) costs and returns for all crops.

A2 Direct Foreign Exchange Costs and Returns for the Homboy Crops and Yields

Tables A1 to A3 show the crop inputs per hectare assumed for Homboy, excluding labour, which has no FE cost. Based on the FE values of crop inputs and outputs shown in Table 4.1, Tables A4 to A8 calculate the FE crop costs and returns and Table A9 presents the net FE returns for each crop.

A3 Other Net Crop Returns

The returns calculated in Section A2 are for the Homboy project; these are also taken to be representative of other large Government projects. Returns have also been estimated for the following other situations:

(a) Rainfed cropping.

(b) Crop production on small-scale private pump schemes. Yields would be lower but so would the levels of input used, especially tractor use.

Tables A10 to A15 show the calculation of rainfed and private pump scheme net returns. FE values in US dollars have been put in parentheses.

A4 Costs of Production for Sugar Cane on JSP II

A4.1 General

Sugar cane crop budgets have been prepared for JSP II on the basis of the projected yield for JSP I and production cost information from JSP and other sources. Crop life has been taken to be the same as that implied in the JSP 1987 budget, roughly 4½ years (i.e. one year plant cane followed by an average length of ratoon of 3½ years). Some 2½% (157 ha) of the JSP II area would be required for seed cane production, leaving a balance of 6 143 ha for productive cane. Of this, 1 365 ha would be under plant cane and 4 778 ha under ratoons.

A4.2 Input Requirements

Following current practices at JSP, input requirements per hectare per annum would be as follows:

		Plant (kg)	Ratoon (kg)
Fertilisers:	Urea	150	200
	DAP	100	-
Herbicides:	Pre-emergence	1	-
	Post-emergence	1	1
Insecticides		1	1
Irrigations by sprinkler		20	20

Seed cane requirements have not been quantified, but their cost is taken into account by including the costs of production of the seed cane area in the overall JSP II costs.

A4.3 Labour Requirements

These are based on current JSP work rates used in the 1987 budget and are shown in Table A16.

A4.4 Machinery Requirements

Table A17 shows the estimated tractor and machinery requirements for sugar cane, based mainly on JSP parameters.

A4.5 Costs of Cane Production

Table A18 shows the costs of cane production.

TABLE A1

Crop Inputs With Project

(Units/ha)

	Unit	Maize	Sesame	Cowpea	Cotton	Onion		Rice		Banana	
										Year 1	Years 2,3,4
Yield	kg	3 000	600	750	1 500	7 000		4 000			
Banana:											
Export	kg									10 000	23 000
Local	kg									2 000	6 000
Waste	kg									500	1 000
Sub-total										12 500	30 000
Seed	kg	20	8	30	25	5		90		2 000	-
										Pieces	
Seed dressing:											
Feraisan D	kg	0.06	0.03	0.10	-	0.02		0.30		-	
Bronopol dust	kg	-	-	-	0.01	-		-		-	
Fertiliser:											
Urea	kg	110	40	-	115	75		160		700	900
DAP	kg	40	25	50	40	50		60		300	-
15.7.24	kg	-	-	-	-	-		-		600	900
Zinc sulphate	kg	1.4	-	-	-	-		-		-	-
Herbicide:											
Strain B4	l	-	-	-	-	-		15		-	-
Pesticide:											
Malathion	kg	3	-	2	-	4		-		-	-
Diazinon	kg	5	-	-	-	-		5		-	-
Polytrin	l	-	-	-	6	-		-		-	-
Ridanol	kg	-	-	-	-	1		-		-	-
Furidan	kg	-	-	-	-	-		-		120	120
Containers	Nr	10	8	5	25	20		22		3 000(2)	6 000(2)
						Gu	Other	Gu	Other		
Labour(1):											
Gu	man-	70	-	53	27	119	5	67	1	94	83
Other season	days	3	53	10	129	35	149	38	104	90	125
Total		73		63	156	154	154	105	105	184	208

Notes: (1) Onions and rice cropped twice each year.
(2) For in-field protection - packing of materials in price for fruit.

Source: Consultants' estimates

TABLE A2

Crop Inputs Without Project
(units/ha)

	Unit	Maize	Sorghum	Sesame		Cowpea		Cotton	Onion	
				Gu	Der	Gu	Der		Gu	Der
Yield	kg	800	600	300	200	250	175	250	2 500	1 750
Seeds	kg	25	10	10	10	35	35	20	6	6
Pesticide: Nuvacron	l	-	-	-	-	-	-	5	-	-
Labour: Gu	man-	45	-	38	-	33	-	54	68	-
Other season	days	-	40	-	31	-	26	-	-	60
Tractor(1)	hours	1	-	-	-	-	-	2	-	-

Note: (1) Cotton, 2 hours land preparation on all land assumed using Somaltex tractor service. Maize, 1 h/ha makes allowance for the fact that not all land is ploughed using existing services - ONAT and private.

Source: Consultants' estimates.

TABLE A3

Crop Machinery Requirements

(Hours/ha)

	Maize	Rice	Sesame	Cowpea	Cotton	Banana Year 1	Banana Years 2,3,4	Onions
Plough:								
- chisel	3.2	3.2	3.2	3.2	3.2	-	-	3.2
- mouldboard	-	-	-	-	-	2.65	-	-
Disc:								
- light(1)	-	-	-	-	-	2.5	-	-
- heavy	2.0	2.0	2.0	2.0	2.0	-	-	2.0
Ridger(2)	0.5		-	-	1.6	18.0	-	0.5
Sowing	-	1.2	-	-	-	-	-	-
Spray	-	0.6	-	-	-	-	-	-
Combine harvester	-	0.9	-	-	-	-	-	-
Transport(3)	0.5	0.9	0.5	0.5	0.5	(4)	(4)	0.5

Notes:
(1) Light discing for bananas as disc harrow in Tables 5 and 6 but with 60 kW tractor.
(2) Assume 1/3 area ridged over whole project for maize and onions.
(3) Including miscellaneous fieldwork costed as tractor and trailer. Except for rice and banana transport, will generally be by ox cart or other farmer arrangement.
(4) Costed as one tractor and trailer full time for 125 ha in Years 2, 3 and 4 and for 250 ha in Year 1.

Source: Consultants' estimates.

TABLE A4

Direct FE Values of Crop Outputs on Homboy Project Crops (US$/ha)

	Crop yield (t/ha)	High prices $/t	High prices Total	Low prices $/t	Low prices Total
With Project (Irrigated crops)					
Maize	3.0	209	627	176	528
Rice	4.0	260	1 040	183	732
Sesame	0.6	890	534	754	452
Cowpeas	0.75	592	444	502	376
Cotton	1.5	653	979	634	951
Vegetables	7.0	-	-	-	-
Bananas (export quality)	19.75	328	6 478	276	5 451
Without Project (Rainfed crops)					
Maize	0.8	209	167	176	141
Sorghum	0.6	195	117	164	98
Sesame: Gu	0.3	890	267	754	226
Sesame: Der	0.2	890	178	754	151

TABLE A5

Direct FE Costs of Seed Inputs for Homboy Project Crops (US$/ha)

	Rate of use (kg/ha)	High prices $/kg	High prices Total	Low prices $/kg	Low prices Total
With Project (Irrigated crops)					
Maize	20	0.209	4.2	0.176	3.5
Rice	90	0.260	23.4	0.183	16.5
Sesame	8	0.890	7.1	0.754	6.0
Cowpeas	30	0.592	17.8	0.502	15.1
Cotton	25	0.200	5.0	0.200	5.0
Vegetables	5	-	-	-	-
Without Project (Rainfed crops)					
Maize	25	0.209	5.2	0.176	4.4
Sorghum	10	0.195	1.9	0.164	1.6
Sesame	10	0.890	8.9	0.754	7.5

TABLE A6

Direct FE Costs of Fertiliser Inputs for Homboy Project (US$/ha)[1]

	kg/ha	US$/kg	Cost per ha
Maize:			
Urea	110	0.258	28.4
DAP	40	0.227	9.1
Zinc sulphate	1.4	0.910	1.3
			38.8
Rice:			
Urea	160	0.258	41.3
DAP	60	0.227	13.6
			54.9
Sesame:			
Urea	40	0.258	10.3
DAP	25	0.227	5.7
			16.0
Cowpeas:			
DAP	50	0.227	11.3
Cotton:			
Urea	115	0.258	29.7
DAP	40	0.227	9.1
			38.8
Vegetables:			
Urea	75	0.258	19.3
DAP	50	0.227	11.3
			30.6
Bananas (average annual rates and costs)			
Urea	850	0.258	219.3
DAP	75	0.227	17.0
17.7.24	825	0.222	183.1
			419.4

Note: (1) Fertiliser use 'without project' is assumed to be negligible.

TABLE A7

Direct FE Costs of Herbicides and Pesticides for Homboy Project Crops (US$/ha)

Crop	Rate per ha	Price per unit ($)	Cost per ha
Maize:			
Malathion	3 kg	1.72	5.2
Diazinon	5 kg	1.39	6.9
			12.1
Rice:			
Stam 34 herbicide	15 l	2.39	35.8
Diazinon	5 kg	1.39	6.9
			42.7
Sesame:	-	-	-
Cowpeas			
Malathion	2 kg	1.72	3.4
Cotton:			
Polytrin	6 l	5.45	32.7
Vegetables:			
Malathion	4 kg	1.72	6.9
Ridomil	1 kg	4.18	4.2
			11.1
Bananas:			
Carbofuran	120 kg	2.11	253.2

TABLE A8

Direct FE Costs of Tractor Operations for Homboy Project Crops (US$/ha)

Crop	Hours per ha	Costs per hours ($)	Cost per ha
With Project			
Maize:			
Chisel plough	3.2	15.4	49.3
Heavy disc harrow	2.0	22.0	44.0
Ridge	0.5	14.3	7.1
Transport	0.5	16.8	8.4
			108.8
Rice:			
Chisel plough	3.2	15.4	49.3
Heavy disc harrow	2.0	22.0	44.0
Combine drill	1.2	25.6	30.7
Spraying	0.6	20.5	12.3
Combine harvest	0.9	40.0	36.0
Transport	0.9	16.8	15.1
			187.4
Sesame:			
Chisel plough	3.2	15.4	49.3
Heavy disc harrow	2.0	22.0	44.0
Transport	0.5	16.8	8.4
			101.7
Cowpeas:			
Chisel plough	3.2	15.4	49.3
Heavy disc harrow	2.0	22.0	44.0
Transport	0.5	16.8	8.4
			101.7
Cotton:			
Chisel plough	3.2	15.4	49.3
Heavy disc harrow	2.0	22.0	44.0
Ridging	1.6	14.3	22.9
Transport	0.5	15.5	7.7
			123.9
Vegetables:			
Chisel plough	3.2	15.4	49.3
Heavy disc harrow	2.0	22.0	44.0
Ridging	0.5	14.3	7.1
Transport	0.5	15.5	7.7
			108.1

TABLE A8 (cont.)

Crop	Hours per ha	Costs per hours ($)	Cost per ha
Bananas (Planting year operations averaged over 4 year crop life):			
Mould board plough	2.65	20.4	54.1
Light disc harrowing	2.5	22.0	55.0
Ridging	18.0	14.3	257.4
			366.5
Average per year			91.6
Transport	5.0	16.2	81.0
Total per annum			172.6
Without Project			
Maize:			
Land preparation	1.0	15.4	15.4

TABLE A9

Direct FE Returns from Homboy Project Crops (US$/ha)

Crop	High Prices			Low Prices		
	Gross returns	Costs	Net returns	Gross returns	Costs	Net returns
With Project						
Maize	627	164	463	528	163	365
Rice	1 040	308	732	732	301	431
Sesame	534	125	409	452	124	328
Cowpeas	444	134	310	376	131	245
Cotton	979	200	779	951	200	751
Vegetables(1)	2 079	-	-	1 764	-	-
Bananas	6 478	845	5 633	5 451	845	4 606
Without Project						
Maize	167	21	146	141	20	121
Sorghum	117	2	115	98	2	96
Sesame: gu	267	9	258	226	7	219
der	178	9	169	151	7	144

Note: (1) The assumption made is that direct FE returns from vegetables would be negligible, as most would be sold on the internal market rather than exported and would also not substitute for imports, and the FE returns would exactly balance the FE costs, net returns thus being zero.

TABLE A10

Net Economic Returns from Rainfed Maize in the Der Season(1) in the Lower Juba (SoSh per ha at 1987 Economic Prices)

Item	High Prices(2)	Low Prices(2)
1. Gross Output		
Yield: 0.5 t/ha Price per tonne	29 200 ($209)	24 800 ($176)
Total	14 600 ($104)	12 400 ($88)
2. Costs of Production		
Seed: 25 kg	1 088 ($5.2)	938 ($4.4)
Fertilizers, herbicides and pesticides	-	-
Sacks (62% of Homboy, based on relative yields)	149 (-)	149 (-)
Tractor operations: As for Homboy 'without project'	1 950 ($15.4)	1 950 ($15.4)
Labour: 40 days at SoSh 80 (the der season economic cost)	3 200 (-)	3 200 (-)
Total costs	6 387 ($20.6)	6 237 ($19.8)
3. Net Return say,	8 213 ($83) 8 200	6 163 ($68) 6 200

Note: (1) The gu season net return is the same as for Homboy.

(2) FE direct benefits/costs in US$ are given in parentheses.

TABLE A11

Net Economic Returns from Maize on Small-Scale Private Pump Schemes (SoSh at 1987 Economic Prices)(1)

Item		High Prices	Low Prices
1. Gross Output			
Yield: 2.25 t/ha			
Price per tonne		29 200 ($209)	24 800 ($176)
Total		65 250 ($470)	55 800 ($396)
2. Costs of Production			
Seed: 20 kg with dressing (as for Homboy)		882 ($4.2)	762 ($3.5)
Fertilizers:	Urea 70 kg	3 073 ($18.1)	3 073 ($18.1)
	DAP 25 kg	975 ($5.7)	975 ($5.7)
	Sub-total	4 048 ($23.8)	4 048 ($23.8)
Herbicides		-	-
Pesticides (75% of Homboy)		1 372 ($9.0)	1 372 ($9.0)
Sacks (75% of Homboy)		450 (-)	450 (-)
Tractor operations: say 3.5 hours at an average cost of SoSh 2 250 ($18.5)		7 875 ($64.7)	7 875 ($64.7)
Labour: 75 days at SoSh 110 (weighted annual average economic price of labour)		8 250 (-)	
Total costs		22 877 ($101.7)	22 757 ($101.0)
3. Net Return		42 373 ($368)	33 043 ($295)
say,		42 400	33 000

Note: (1) FE direct costs and returns in US dollars are given in parentheses.

TABLE A12

Net Economic Returns from Rice on Small-Scale Private Pump Schemes (SoSh per ha at 1987 Economic Prices)[1]

Item	High Prices	Low Prices
1. Gross Output		
Yield: 3.0 t/ha paddy Price (SoSh/tonne)	32 200 ($260)	22 300 ($183)
Total	96 600 ($780)	66 900 ($549)
2. Costs of Production		
Seed (90 kg) and seed dressing (as for Homboy)	4 409 ($23.4)	3 077 ($16.5)
Fertilisers: Urea 125 kg	5 487 ($32.2)	5 487 ($32.2)
DAP 40 kg	1 312 ($9.1)	1 312 ($9.1)
	6 799 ($41.3)	6 799 ($41.3)
Herbicides	-	
Pesticides (as for Homboy)	1 050 ($42.7)	1 050 ($42.7)
Sacks (75% of Homboy)	990 (-)	990 (-)
Tractor operations: say 4 hours at an average cost of SoSh 2 250 ($18.5)	9 000 ($74.0)	9 000 ($74.0)
Labour[2]: 160 days at SoSh 110 (weighted annual average economic price of labour)	17 600 (-)	17 600 (-)
Total costs	39 848 ($181.4)	38 516 ($174.5)
3. Net Return before irrigation costs	56 732 ($599)	28 384 ($374)
say,	56 800	28 400

Notes: (1) Direct FE costs and returns in US dollars are shown in parentheses.

(2) Based on 10 labour days for land preparation and planting, 25 days for weeding, 15 for irrigation, 30 for harvest and post-harvest operations, 70 for bird scaring and 10 for miscellaneous tasks.

TABLE A13

Net Economic Returns from Sesame on Small-Scale Private Pump Schemes (SoSh per ha at 1987 Economic Prices)(1)

Item	High prices		Low prices	
1. Gross Output				
Yield: 0.45 t/ha				
Price per tonne	124 300	($890)	106 300	($754)
Total	55 935	($400)	47 835	($339)
2. Costs of Production				
Seed: 8 kg as for Homboy 'with project'	1 498	($7.1)	1 282	($6.0)
Fertilizers: Urea 20 kg	878	($5.2)	878	($5.2)
DAP 10 kg	390	($2.3)	390	($2.3)
	1 268	($7.5)	1 268	($7.5)
Herbicides	-		-	
Pesticides	-		-	
Sacks (75% of Homboy)	360	(-)	360	(-)
Tractor operations: say 2.5 hours at an average cost of SoSh 2 250 ($18.5)	5 630	($46.2)	5 630	($46.2)
Labour: 48 days at SoSh 110 (weighted annual average economic price of labour)	5 280	(-)	5 280	(-)
Total costs	14 036	($60.8)	15 318	($59.7)
3. Net Return before irrigation costs	41 899	($339)	32 517	($279)
say,	41 900		32 500	

Note: (1) Direct FE costs and returns in US dollars are shown in parentheses.

TABLE A.14

Net Economic Returns from Onions (Vegetables) on Small-Scale Private Pump Schemes (SoSh per ha at 1987 Economic Prices)

Item	High prices	Low prices
1. Gross Output		
Yield: 5.0 t/ha		
Price per tonne	41 500	
Total	207 500	177 500
2. Costs of Production		
Seed (5 kg) as for Homboy	316	316
Fertilizers: Urea 60 kg	2 634	2 634
DAP 40 kg	1 560	1 560
	4 194	4 194
Herbicides	-	
Pesticides (70% of Homboy)	1 169	1 169
Sacks (70% of Homboy)	840	840
Tractor operations: say 4 hours at an average cost of SoSh 2 250	9 000	9 000
Labour: 140 days at SoSh 110 (weighted annual average economic price of labour)	15 400	15 400
Total costs	30 919	30 919
3. Net Return before irrigation costs	176 581	146 581
say,	176 600	146 600

Note: (1) Onions have been taken as representative of all vegetables and also crops like tobacco.

TABLE A15

Net Economic Returns from Pulses on Small-Scale Private Pump Schemes (SoSh per ha at 1987 Constant Prices)

	Item	High prices		Low prices	
1.	Gross Output				
	Yield: 0.5 t/ha	82 800	($592)	70 800	($502)
	Price per tonne	41 400	($296)	35 400	($251)
	Total				
2.	Costs of Production				
	Seed (30 kg), as for Homboy 'With Project'	3 730	($17.8)	3 190	($15.1)
	Fertilizers: DAP 25 kg	970	($5.7)	970	($5.7)
	Herbicides and agro-chemicals	-	-	-	-
	Sacks (67% of Homboy)	200	-	200	-
	Tractor operations: as for sesame	5 630	($46.2)	5 630	($46.2)
	Labour: 57 days at SoSh 110 (weighted annual average economic price of labour)	6 270	-	6 270	-
	Total costs	16 800	($69.7)	16 260	($67.0)
3.	Net Return	24 600	($226.3)	19 140	($184)
	say,	24 600	($226)	19 100	($184)

TABLE A.16

Sugar Cane Labour Requirements (Man-days per hectare)

Operation	Plant cane	Ratoon
Seed cutting, piling, preparation, loading and laying and covering in furrows after covering by machine	58.0	-
Herbicide applications at 1.5 days per application	3.0	1.5
Insecticide application	1.5	1.5
Fertiliser application at 2.5 days per application	5.0	2.5
Hand weeding at 30 days per ha weeded	60.0	30.0
Irrigation at 2 days/ha	40.0	40.0
Gealining	5.0	5.0
Cane burning and marking	1.0	1.0
Crop residue removal	7.0	5.0
Total excluding cutting	180.5	86.5
Cutting (loading is by machine)	0.8 d/t of cane	

TABLE A.17

Machinery Operations for Sugar Cane (hours per hectare)

Operation	Plant cane	Ratoon
Install infield traces and V-drains, with motor-grader	0.6	-
Ripping with D7, on 15% of the area: 4 h/ha x 0.15	0.6	-
Ploughing with D6 and Rome plough	3.0	-
2 harrowings with wheeled tractor	4.0	-
Furrowing with wheeled tractor	2.0	-
Transport of seed cane by tractor and trailer	2.0	-
Covering after planting, with wheeled tractor	2.0	-
Ridging with wheeled tractor	2.0	2.0
Miscellaneous work with wheeled tractor (transport of inputs, etc.)	1.0	0.5
Total excluding harvesting	19.2	2.5
Cane loading with Cameco loader	16 t/h	
Cane transport (tractor with 2 trailers)	5.5 t/h	

TABLE A18

Costs of Cane Production
(SoSh 000/ha)

Item	Plant cane Cost	Plant cane Direct FE (US$)	Ratoon Cost	Ratoon Direct FE (US$)
1. Inputs (excluding irrigation)				
Fertilisers: Urea, at SoSh 43.9/kg	6.58	39	8.78	52
DAP, at SoSh 39/kg	3.90	23	-	-
Herbicides(1)	10.80	72	5.40	36
Insecticides	1.42	9	1.42	9
Sub-total	22.70	143	15.60	97
2. Labour				
(a) Pre-harvesting				
At weighted average economic wage rate of SoSh 110/day	19.85	-	9.51	-
(b) Harvesting				
At premium economic wage rate of SoSh 160/day and assuming 105 t/ha for all crops	16.80	-	16.80	-
Sub-total	36.65		26.31	
3. Machinery				
(a) Pre-harvesting				
15 hours of wheeled tractor work at SoSh 2 050/hour	30.75	243	5.30 (2.5 hours)	121
0.6 hours of motorgrader at SoSh 2 460(2)	1.48	19	-	-
3.0 hours of D6 crawler at SoSh 3 640(2)	11.07	29	-	-
0.6 hours of D7 crawler at SoSh 4 100(2)	2.46	19	-	-
Sub-total of (a)	45.76	310	5.30	121
(b) Harvesting (105 t/ha yield)				
6.6 hours of cane loader at SoSh 2 150/h(2)	13.53	107	13.53	107
19.1 hours of cane transport at SoSh 2 050/h	39.15	309	39.15	309
Sub-total of (b)	52.68	416	52.68	416
Total (a) + (b)	98.44	726	57.98	537

TABLE A.18 (cont.)

Item	Plant cane Cost	Plant cane Direct FE (US$)	Ratoon Cost	Ratoon Direct FE (US$)
4. Total Pre-Harvest Costs				
Per hectare	88.31	453	30.41	218
Annual average per ha of cane (1 plant crop plus 3.5 ratoons)	43.28	270		
Annual average per ha of total estate, allowing for 2.5% of the area being under seed cane	44.39	277		
5. Harvesting Costs				
Per tonne of cane	0.85	4		
Per hectare harvested	89.33	416		
Per hectare of total estate	91.62	427		
6. Total costs at 105 t/ha cane yield				
Cane yield per hectare of total estate	102.4 t			
Cost per tonne of cane	1.33	7		
Cost per hectare of total estate	136.21	704		

Note: (1) Based on the Homboy cost of SoSh 5 400 per application, for rice.

(2) Based on the ratios between the unit costs of wheeled tractors and these other types of machinery, estimated from Table 12 of the JSP 1987 budget, and the standard tractor economic cost of SoSh 2 050/h assumed. Cane loader costs are similar to those of wheeled tractors plus equipment.

APPENDIX B

CONTROLLED DESHEK FLOODING WITH BARDHEERE

B.1 Introduction

This appendix reviews some of the earlier operational studies and analyses the scope for controlled flooding of deshek areas when the Bardheere dam becomes operational. Details of the operational studies of Bardheere reservoir are given in the report "Bardheere Dam Project Design Studies' (Electroconsult, 1986). Subsequent to the design studies of Bardheere dam, AHT analysed the effects of Bardheere dam on the development of the desheks and also specified the shape of an artificial flood wave to be released from the dam to meet the water demand of the deshek areas, (AHT, 1986).

In the studies presented here, a routing model was developed and used to analyse the effect on power production of a flood wave released from Bardheere reservoir. The routing analysis was carried out for the der season during selected periods but it should be extended to the whole period of records on a daily basis (1951 to 1983) in order to refine the analysis.

B.2 Flow Data

Flow measurements have been made upstream of the reservoir at Lugh Ganana and at Bardheere, 30 km downstream of the dam. The flow at Bardheere is more representative for the operational studies, but the record is short (1963 to 1983) and there are several gaps. The measurements at Lugh Ganana date back to 1951 but the data are not continuous in certain years. Therefore, common data sets for the period 1963 to 1983 at each site were used to obtain a linear relationship between the flows. The regression model was used to simulate flows at Bardheere, using the flows at Lugh Ganana, for 1951 onwards.

Daily flows in March were considered to be representative of the gu season while the flows in September and October were used as samples for the der season. The general regression equation for estimating flows at Bardheere using the flows at Lugh Ganana is given by:

$$Q_B = M Q_L + C$$

where Q_B = daily flow at Bardheere in m^3/s

Q_L = daily flow at Lugh Ganana in m^3/s

M, C = coefficients

The estimated coefficients are given in Table B.1.

TABLE B.1

Flow Regression

Month	Nr of years of data used	Coefficients M	Coefficients C	Correlation coefficient
April	6	0.82	29.4	0.97
September	11	0.85	16.5	0.92
October	10	0.72	62.8	0.89

A sample fitted curve for September is given in Figure B.1.

B.3 Control Flood

AHT recommended the following release rules (Table B.2) from the reservoir to adequately flood the desheks.

TABLE B.2

Reservoir Release for Deshek Flooding (m^3/s)

Day	1	2	3	4	5	6	7	8	9	10	11
Discharge	84	84	84	182	295	316	338	361	384	408	433
Day	12	13	14	15	16	17	18	19	20	21	22
Discharge	459	485	512	539	568	597	459	338	199	84	84
Day	23	24	25								
Discharge	84	84	84								

Design flooding of the desheks commenced when water levels corresponding to a discharge of 300 m^3/s at Bardheere are reached. Peak controlled flooding is reached when 600 m^3/d is released from Bardheere. The total period of flooding is 15 days. AHT allowed a minimum discharge of 84 m^3/s to meet 60% of the firm power demand. In this study, however, a minimum discharge of 135 m^3/s is specified, in order to meet the full power demand.

B.4 Present Flooding Pattern

The periods of uncontrolled deshek flooding when Bardheere discharges exceed 300 m^3/s and 600 m^3/s are shown in Tables B.3 to B.6. These tables are based on the historical data series for the period 1951 to 1983 at Lugh Ganana. It is evident that the probabilities of exceeding 300 m^3/s in the gu and der seasons are 0.68 and 0.96 respectively. Similarly, the probability of exceeding 600 m^3/s in the gu and der seasons are 0.24 and 0.54 respectively.

FIGURE B.1

BARDHEERE & LUGH FLOW RELATION(SEP)

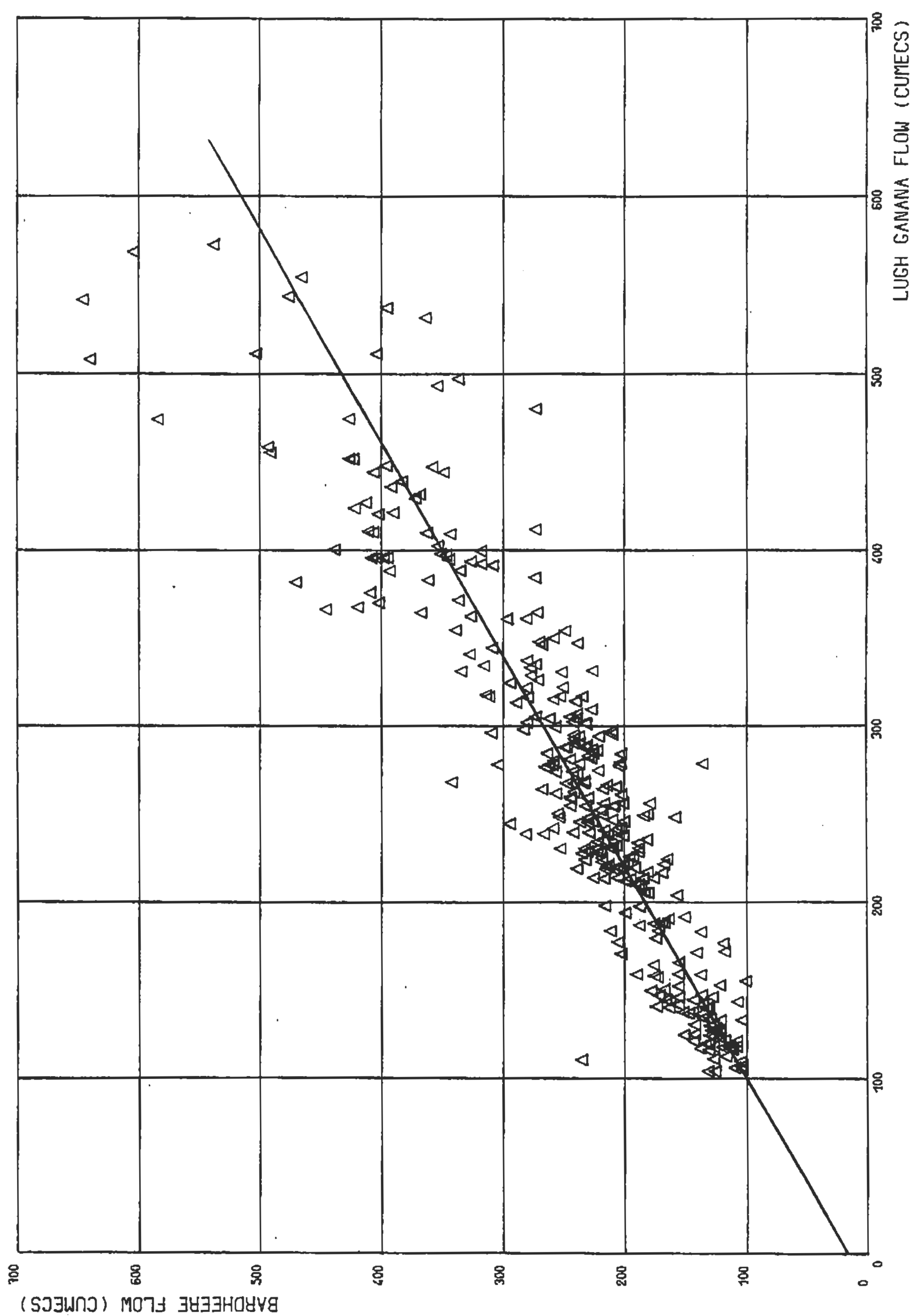


TABLE B3

Duration of Flows Exceeding 300 m^3/s at Bardheere in Gu Season

Year	Duration in days				
	Mar	Apr	May	Jun	Total
1951	0	12	27	4	43
1952	0	0	2	0	2
1953	0	0	2	0	2
1954	0	8	4	0	12
1955	0	0	0	0	0
1956	0	(3)	7	0	10
1957	0	9	18	11	38
1958	0	0	0	0	0
1959	-	-	-	-	-
1960	-	-	-	-	-
1961	-	-	-	-	-
1962	0	0	0	0	0
1963	-	-	-	-	-
1964	0	0	0	2	2
1965	0	0	0	0	0
1966	0	5	5	0	10
1967	-	-	-	-	-
1968	-	-	-	-	-
1969	-	-	-	-	-
1970	0	10	16	0	26
1971	-	-	-	-	-
1972	0	1	16	6	23
1973	0	0	0	0	0
1974	0	0	3	0	3
1975	0	0	0	0	0
1976	0	0	23	5	28
1977	0	10	13	16	39
1978	0	0	12	0	12
1979	-	-	-	-	-
1980	0	0	0	0	0
1981	3	29	21	0	53
1982	-	-	-	-	-
1983	-	-	-	-	-

Notes: - Data incomplete and excluded from analysis.
( ) Estimated values.

TABLE B4

Duration of Flows Exceeding 600 m^3/s at Bardheere in Gu Season

Year	Duration in days				
	Mar	Apr	May	Jun	Total
1951	0	2	5	0	7
1952	0	0	0	0	0
1953	0	0	0	0	0
1954	0	0	0	0	0
1955	0	0	0	0	0
1956	0	0	0	0	0
1957	0	4	2	0	6
1958	0	0	0	0	0
1959	-	-	-	-	-
1960	-	-	-	-	-
1961	-	-	-	-	-
1962	-	-	-	-	-
1963	-	-	-	-	-
1964	0	0	0	0	0
1965	0	0	0	0	0
1966	0	0	0	0	0
1967	-	-	-	-	-
1968	-	-	-	-	-
1969	-	-	-	-	-
1970	0	0	0	0	0
1971	0	0	0	0	0
1972	0	0	0	0	0
1973	-	-	-	-	-
1974	0	0	0	0	0
1975	0	0	0	0	0
1976	0	0	5	0	5
1977	0	1	0	2	3
1978	0	0	0	0	0
1979	-	-	-	-	-
1980	0	0	0	0	0
1981	0	16	9	0	25
1982	-	-	-	-	-
1983	-	-	-	-	-

Notes: - Data incomplete and excluded from analysis.

TABLE B5

Duration of Flows Exceeding 300 m^3/s at Bardheere in Der Season

Year	Duration in days				
	Sept	Oct	Nov	Dec	Total
1951	2	22	30	14	58
1952	25	(28)	5	0	58
1953	0	3	17	0	20
1954	23	31	0	0	54
1955	5	23	2	0	30
1956	21	29	8	0	58
1957	0	(6)	(8)	6	20
1958	30	30	11	0	71
1959	22	22	18	0	62
1960	-	-	-	-	-
1961	30	31	30	21	112
1962	-	-	-	-	-
1963	0	0	2	11	13
1964	3	25	7	5	40
1965	0	23	22	0	45
1966	20	8	6	0	34
1967	-	-	-	-	-
1968	-	-	-	-	-
1969	-	-	-	-	-
1970	23	31	15	0	69
1971	0	28	24	0	52
1972	0	11	27	0	38
1973	-	-	-	-	-
1974	13	0	0	0	13
1975	15	22	1	0	38
1976	0	0	18	0	18
1977	22	23	30	7	82
1978	5	29	13	-	47
1979	-	-	-	-	-
1980	0	0	0	0	0
1981	24	27	0	0	51
1982	-	-	-	-	-
1983	-	-	-	-	-

Notes: - Data incomplete and excluded from analysis.
( ) Estimated values.

TABLE B6

Duration of Flows Exceeding 600 m^3/s at Bardheere in Der Season

Year	Duration in days				
	Sept	Oct	Nov	Dec	Total
1951	0	10	1	0	11
1952	0	9	0	0	9
1953	0	0	0	0	0
1954	3	5	0	0	8
1955	0	0	0	0	0
1956	0	15	2	0	17
1957	0	0	0	0	0
1958	0	1	0	0	1
1959	1	10	9	0	20
1960	-	-	-	-	-
1961	0	6	16	4	26
1962	-	-	-	-	-
1963	0	0	0	0	0
1964	0	6	0	0	6
1965	0	11	1	0	12
1966	0	0	0	0	0
1967	-	-	-	-	-
1968	-	-	-	-	-
1969	-	-	-	-	-
1970	0	7	8	-	15
1971	0	9	2	0	11
1972	0	0	0	0	0
1973	-	-	-	-	-
1974	0	0	0	0	0
1975	0	0	0	0	0
1976	0	0	0	0	0
1977	0	10	21	0	31
1978	0	13	0	0	13
1979	-	-	-	-	-
1980	0	0	0	0	0
1981	0	0	0	0	0
1982	-	-	-	-	-
1983	-	-	-	-	-

Notes: - Data incomplete and excluded from analysis.

Table B.3 also indicates that for 4 years the effective flooding period is less than 3 days, which is marginal for flooding the desheks effectively. These periods can be excluded in comparing the overall probability. This will reduce the probability of exceeding 300 m^3/s to 0.50 in the gu season.

The conditional probability distribution of time-of-submergence for the der season is given in Figures B.2 and B.3 for flows of 300 m^3/s and 600 m^3/s respectively. Tables B.7 and B.8 present the period of submergence for flows of 300 m^3/s in the der and gu seasons.

TABLE B.7

Duration of Flows Exceeding 300 m^3/s in Der Season
Probability of Exceedance = 0.96

Return period (years)	Probability of exceedance (%)	Duration (days)
2	50	42
5	20	61
10	10	69
25	4	87
50	2	104

TABLE B.8

Duration of Flows Exceeding 300 m^3/s in Gu Season
Probability of Exceedance = 0.68

Return period (years)	Probability of exceedance (%)	Duration (days)
2	50	5
5	20	16
10	10	21
25	4	27
50	2	31

B.5 Flood Routing

The flood routing studies carried out by Electroconsult were done on a monthly basis and showed that, for the period 1951 to 1953, the reservoir reached its spill level of 141.90 m in 25 of the 33 years.

In order to test the possibility of controlled flooding post-Bardheere in the der season a routing model was developed using the reservoir release scheme recommended by AHT and shown in Table B.2. October was taken as the month for commencement of flooding and the routing was carried out for the 16 years of available daily flow records.

It was found that controlled flooding could be achieved in 12 of the 16 years without affecting the availability of reservoir discharges needed to meet the firm demand (135 m^3/s) for hydro-electric power.

For the gu season the situation is quite different, since the normally not very voluminous floods have to be stored for power generation. Releases for controlled flooding would therefore jeopardise power generation in subsequent months and thus cannot be considered.

B.6 Conclusions

For the der season uncontrolled flooding of the desheks can currently be achieved in most years. After the construction of Bardheere dam flooding will still be possible by controlling releases from the reservoir, although the probability of flooding in any one year will be reduced to about 75%.

The present level of flooding in the gu season is much lower than the der, and since controlled flooding with Bardheere would not be feasible, construction of the dam would virtually eliminate flood-recession cropping in the gu season.

Figure B.2

Period of Submergence in Der Season for Discharge Exceeding 300 m^3/s at Bardheere

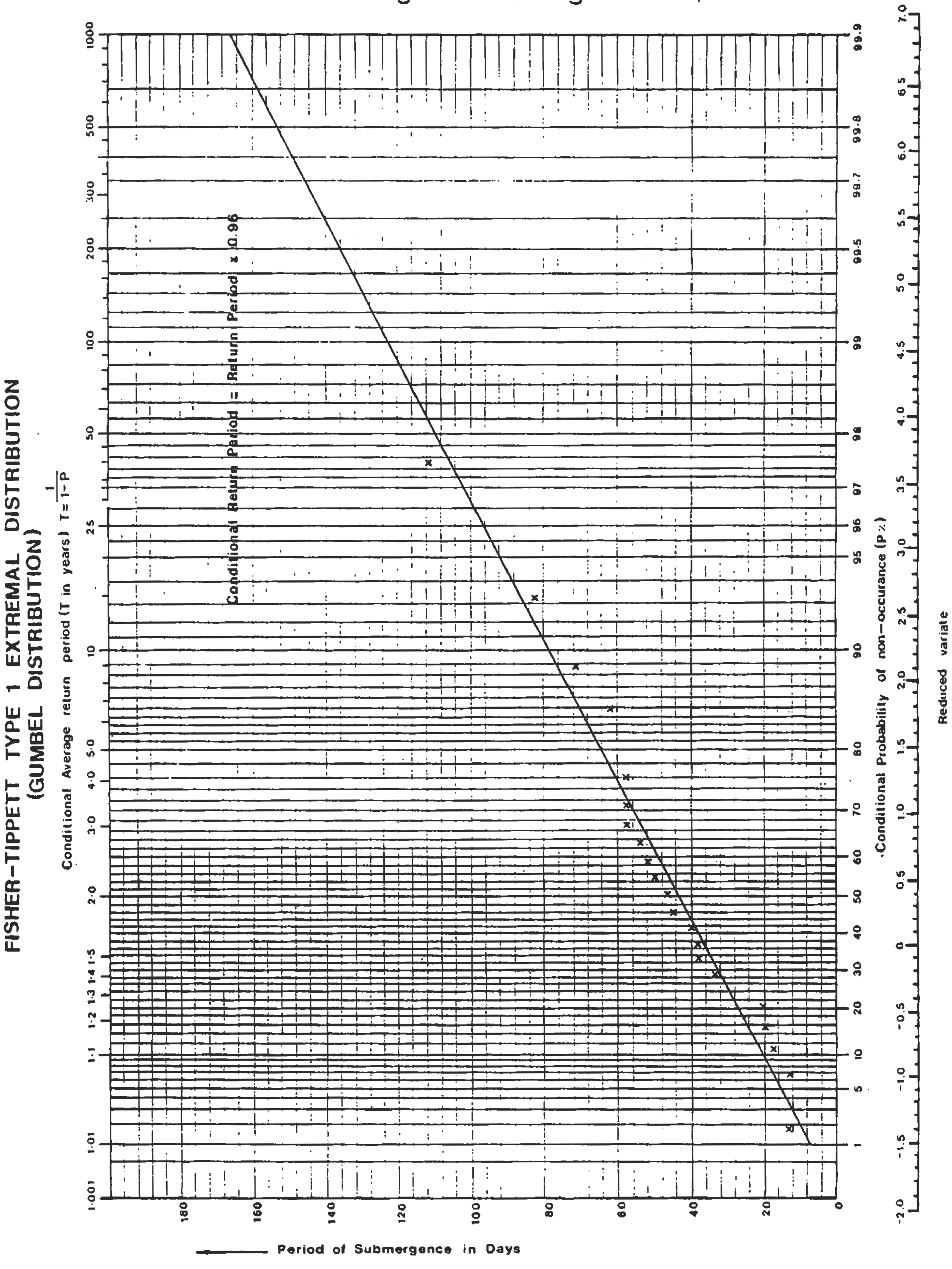


Figure B.3

Period of Submergence in Der Season for Discharge Exceeding 600 m^3/s at Bardheere